BELL TELEPHONE QUARTERLY

VOL. XVIII APRIL, 1939 NO. 2

ON WATCH—ALL OVER THE MAP

THE GEOGRAPHY OF THE BELL TELEPHONE LABORATORIES

AIDS TO THE HARD OF HEARING

DIRECTORY PAPER PURCHASING

WORLD'S TELEPHONE STATISTICS

AMERICAN TELEPHONE & TELEGRAPH CO. • NEW YORK

BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

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Contributors to This Issue

HERMAN D. HOCKER

John Herron Art Institute, Indianapolis, Indiana, 1918. Columbia University, studies in journalism and fine arts, 1919–1923. American Telephone and Telegraph Company, Long Lines Department, General Plant Office, New York, 1923; *Long Lines Magazine* staff, 1924, Assistant Editor, 1926, Art Editor, 1928, Editor, 1928–1937; Advertising Supervisor, 1937.

R. LINSLEY SHEPHERD

Sheffield Scientific School, Yale University, Ph.B., 1919. Yale Graduate School, 1919–1920. Public Service Electric Company of New Jersey, Engineer, 1920–1922. *Electrical World,* McGraw-Hill Publishing Company, Assistant Engineering Editor, Southern Editor, Market Analysis Research, 1922–1929. Bell Telephone Laboratories, Bureau of Publication, 1929–. Bell System Exhibit, Century of Progress, Chicago, Engineer of Exhibits, 1933.

R. F. DAVIS

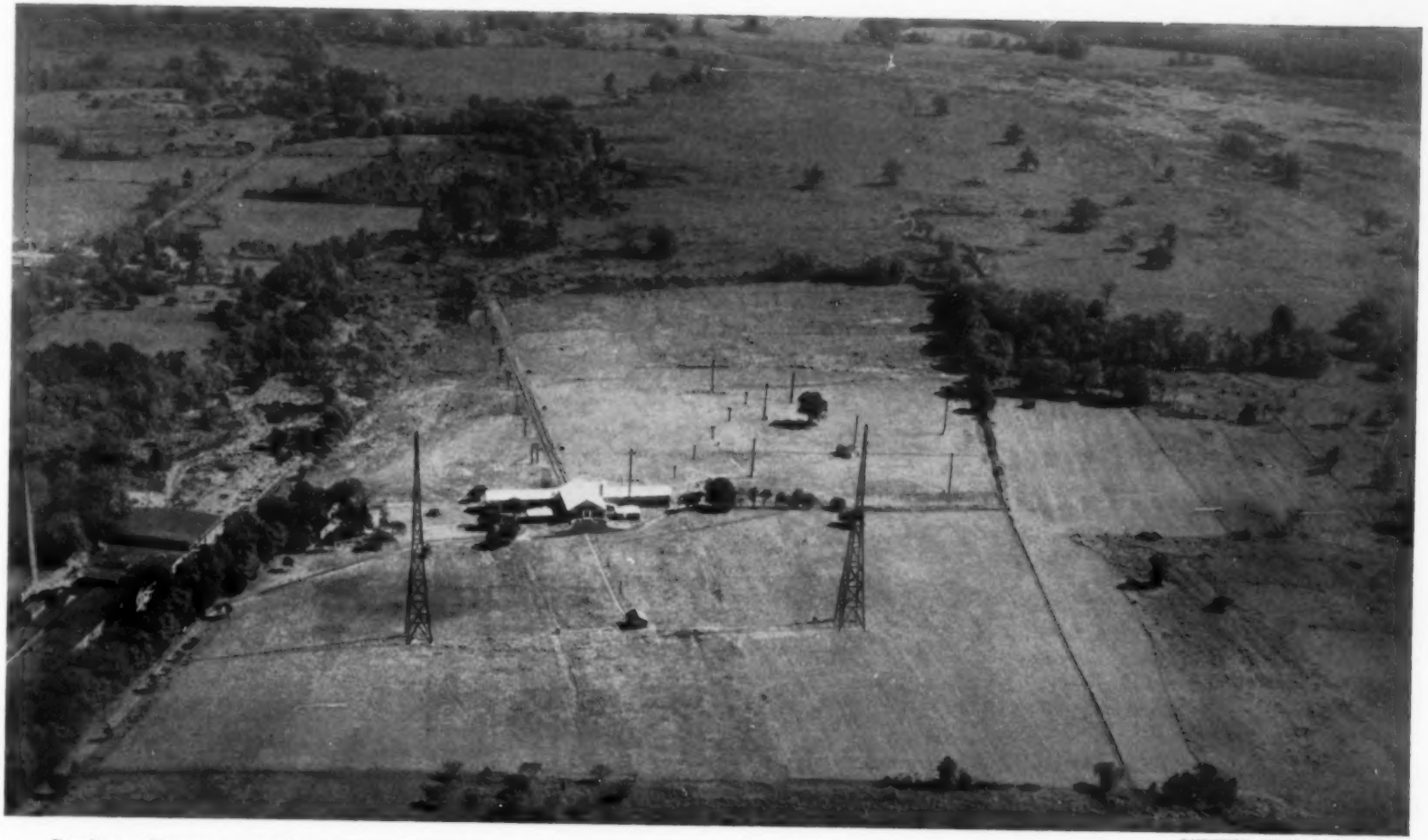
Cornell University, B.E.E., 1921. American Telephone and Telegraph Company, Department of Operation and Engineering, 1921–. From 1921 to 1938 Mr. Davis' work was largely concerned with the electrical protection of communications circuits and with the electrical coordination of such circuits with power transmission and distribution circuits. Since 1938 he has been engaged in problems dealing with local transmission and special services.

M. P. WOODARD

Armour Institute of Technology, 1918–1921. B. F. Goodrich Rubber Co.—Mechanical Goods Division, 1921–1929. Western Electric Company, General Purchasing Department, 1929–.

K. FICK

Hellerup Gymnasium, Copenhagen, Denmark, B.A., 1916; University of Copenhagen, Cand.Ph., 1918. Danish Government Service, 1918–1924. American Telephone and Telegraph Company, Chief Statistician's Division, 1925–.



FAIRCHILD AERIAL SURVEYS, INC.

BIRD'S-EYE VIEW OF THE WHIPPANY LABORATORY, FIELD HEADQUARTERS OF THE BELL TELEPHONE LABORATORIES FOR THE DEVELOPMENT OF BROADCASTING TRANSMITTERS AND AIRCRAFT COMMUNICATION EQUIPMENT. SEE "THE GEOGRAPHY OF THE BELL TELEPHONE LABORATORIES," PAGE 95

On Watch—All Over the Map

Editor's note: Since the first of the year, groups of telephone people have been able to witness at Long Lines Headquarters a dramatized presentation of the functions of the Traffic Control System. To give readers of the QUARTERLY *some idea of these informative demonstrations, the following article was prepared by one of the "dramatis personnae."*

CONSIDER the sad case of Argus, that personage in Greek mythology who had a hundred eyes, quarreled with a jealous goddess, and forthwith found his prized orbs destined to serve forever as decorations on the peacock's tail. Poor Argus of Mount Olympus was endowed to watch everything, but seems to have found no occupation worthy of his talents.

Argus would feel more at home in the Bell System today. Or perhaps not. For he would discover mere mortals outdoing him in both fancy and fact as they watch over long distance telephone circuits. This responsibility enters into the jobs of a great many telephone workers, of course: testboardmen, section linemen, and engineers, to name a few.

One other group might well have even less reverence for Argus. These particular people—men and women—operate the Traffic Control System which is maintained by the Long Lines Department to direct and coördinate the movement of telephone traffic over more than two and a half million miles of talk highways. On this network about 100 long distance calls—averaging nearly 250 miles in length—whizzed back and forth every single minute during 1938: that is to say, this would have been the minute-by-minute count on calls placed if the total volume had been spread evenly throughout the year.

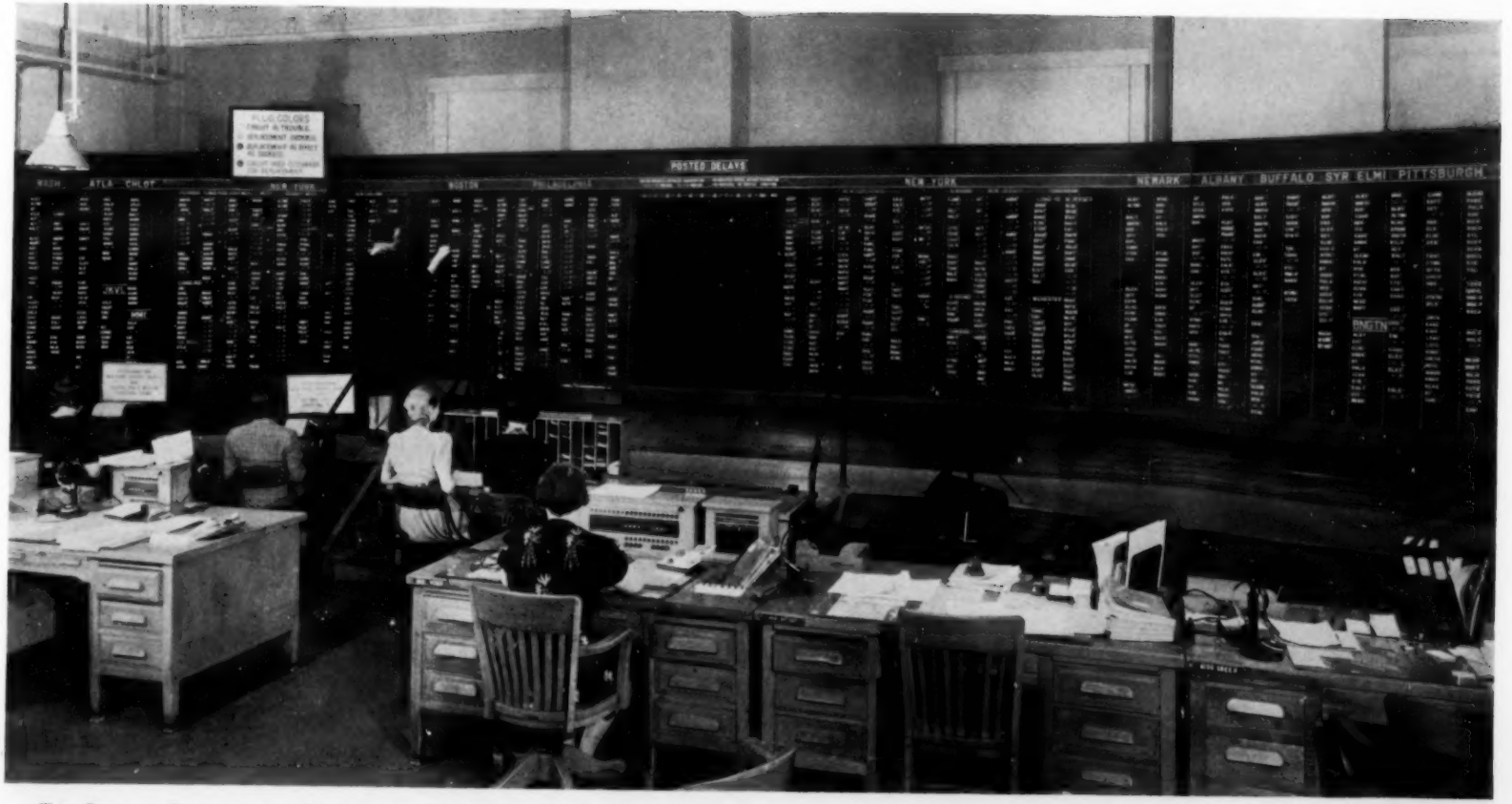
But telephone traffic is never so ideally distributed—and that's where the Traffic Control System fits in. The country-wide circuit layout has been engineered to meet average traffic

requirements, but every day—and, indeed, almost every hour —brings variations from average. In the interests of uniform service and to make the most efficient use of the facilities available, it is frequently necessary to make layout rearrangements and route structure changes. Some of these rearrangements can be planned in advance—such as those necessitated by scheduled conventions or sporting events. Other adjustments, however, must be made on an emergency basis because of unpredictable changes in traffic flow and because of circuit failures.

Many situations require give and take between widely scattered telephone offices in order to even out possible delays to traffic movement. Judgment can be based only on a view of the picture as a whole, which makes it important that authority to make decisions and to take action be centralized. This authority is vested in the three Traffic Control Bureaus which make up the Control System. Located at New York, Chicago, and Cleveland, the Bureaus are in constant touch with operating rooms in their areas—and with each other—by telephone and teletype. By this means they receive current information on circuit and traffic conditions.

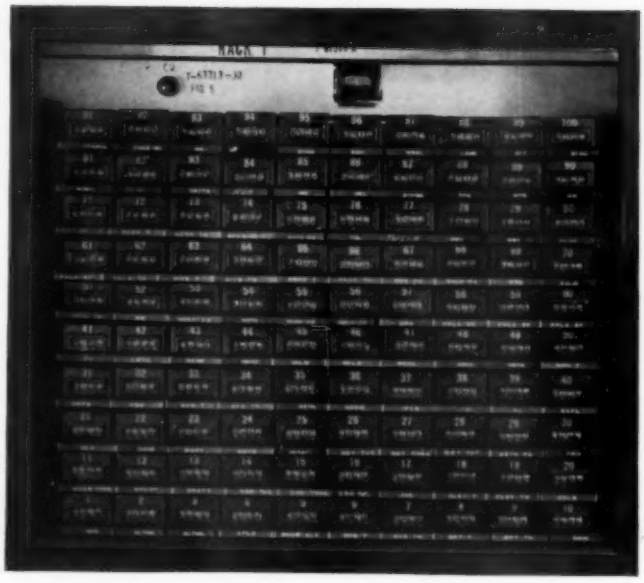
As a result of up-to-the-minute checks, combined with office records, charts and "display boards," each Bureau constantly maintains a bird's-eye view of the situation in its area in relation to the network as a whole.

A brand of foresight exceeding the powers of a hundred eyes is required on this job, so Argus need not apply. Granting him perfect vision beneath that classic brow, he almost certainly would fail the *mind's*-eye test. If his pride permits, however, he is invited to sit quietly with us in the New York Bureau, to watch the Traffic Control System meet one of its most important responsibilities on a day especially chosen to deflate the Argus ego. The day is a flashback to a date, on the calendar of a year or so ago, which brought a cable failure



THE DISPLAY BOARD OF THE TRAFFIC CONTROL BUREAU AT THE LONG LINES DEPARTMENT HEADQUARTERS IN NEW YORK CITY, WHEREON ARE REPRESENTED ALL OF THE LONG LINES MESSAGE CIRCUITS TERMINATING IN OFFICES OF THE EASTERN TRAFFIC DIVISION

CLOSE-UP OF A SECTION OF THE NEW YORK DISPLAY BOARD, THE PLUGS OF DIFFERENT COLORS AND SHAPES INDICATING THE CIRCUITS "OD" TO THE SOUTH AND WEST AS A RESULT OF THE CABLE FAILURE IN PENNSYLVANIA



"ALL TRUNKS BUSY" REGISTERS WHICH SHOW, CUMULATIVELY FOR EACH GROUP, THE AMOUNT OF TIME DURING WHICH NO CIRCUITS ARE AVAILABLE TO THE SWITCHBOARD OPERATORS

THE DISPLAY BOARD OF THE TRAFFIC CONTROL BUREAU AT DIVISION TRAFFIC HEADQUARTERS IN CLEVELAND

THE DISPLAY BOARD OF THE TRAFFIC CONTROL BUREAU AT DIVISION TRAFFIC HEADQUARTERS IN CHICAGO

serious enough to threaten long distance telephone service in cities all across the land.

It is 9:05 A.M. A wintry morning. The New York Chief Testboardman calls the Supervisor of the Bureau. We catch ominous words. . . .

"Looks as though we're losing the Harrisburg-Pittsburgh cables. Trouble came in about fifteen minutes ago—Harrisburg-Shippensburg section. . . . The B cable looks like a total failure, with a few pairs out in the A, but I don't know what they are yet. . . . Circuits crossed and grounded. . . . I'll have to call you later.". . .

"OK, we'll get busy!"

NY TO CGO AND CLEV

TOTAL FAILURE OF HBG-SHIPP B CABLE. FEW LOST IN A. WILL CALL IN A SHORT WHILE. PLEASE STAND BY FOR CONF.

EMG

OK CGO

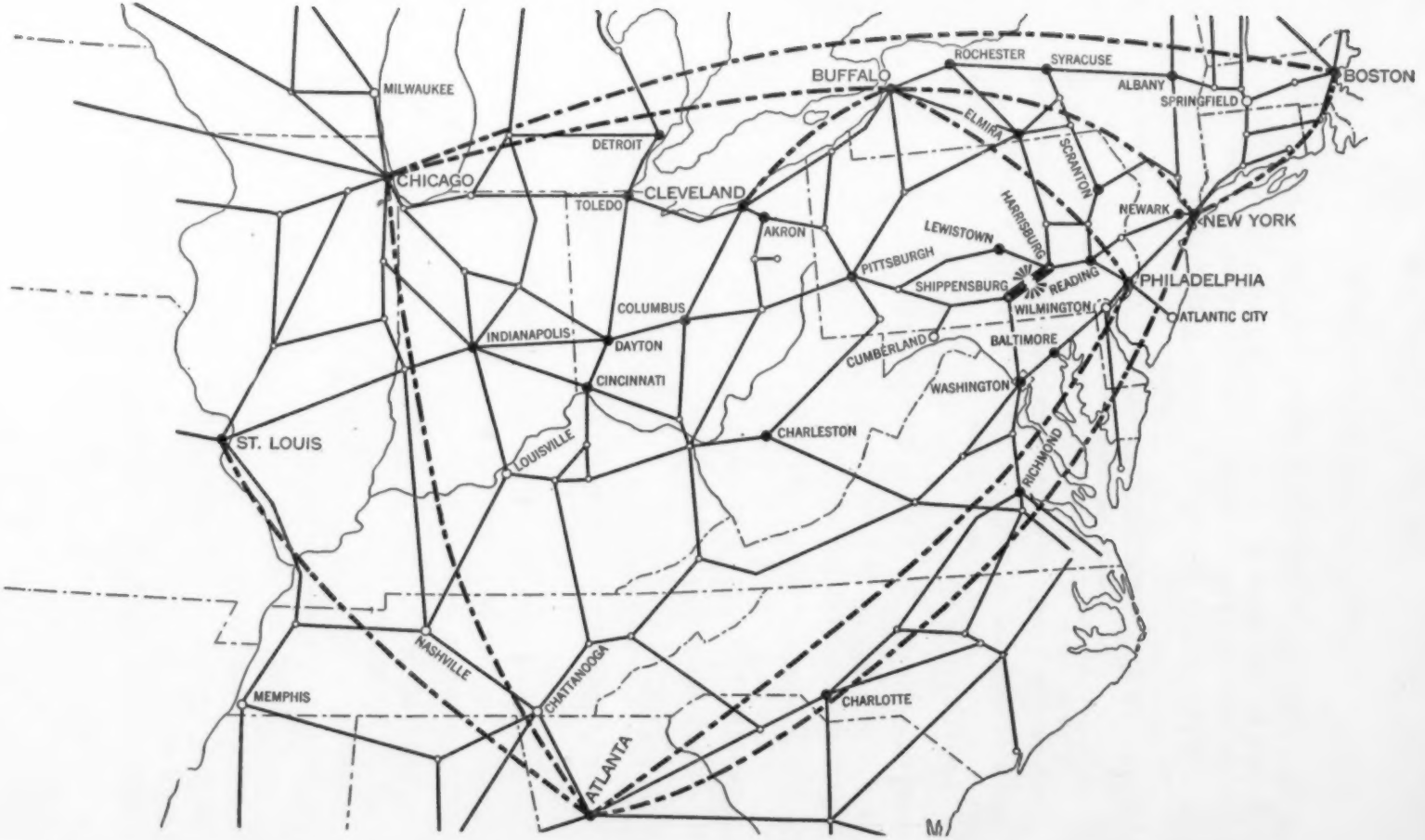
OK CLEV

The Bureau does get busy, but with orderly speed. Key people gather 'round and quickly agree on the first moves to be made. How many and exactly which circuits are routed through these cables? What per cent of each circuit group is affected? Can the total circuit casualties be estimated? Bureau records yield the answers, and they are included in a preliminary report telephoned immediately to the General Traffic Manager's office:

". . . Cable failure between Harrisburg and Shippensburg. 8:55 A.M. About 156 circuits affected. The worst groups are Pittsburgh-Harrisburg, 3 short out of 4. Pittsburgh-New York, short 17 out of 26. . . . No cause or prospects yet. . . ."

Nimble fingers post the same story in colored plugs on the New York Display Board. (Likewise, the Cleveland and

THE CABLE BREAK IN PENNSYLVANIA SHOWN ON THIS MAP AFFECTED MANY OF THE LONGEST AND BUSIEST DIRECT TELEPHONE CIRCUITS IN THE COUNTRY, AS INDICATED SCHEMATICALLY BY THE HEAVY LINES



BRIDGING THE GAP CAUSED BY THE CABLE FAILURE IN PENNSYLVANIA: THE HEAVY BROKEN LINES SHOW HOW CIRCUITS WERE BUILT UP TO RE-ROUTE CALLS WHILE THE DIRECT LINES WERE OUT OF SERVICE

Chicago Bureaus will soon have posted their boards for circuits affected in their areas.)

Now with a visual interpretation before us, we see that enough circuits remain intact to handle traffic comfortably at

DATE ISSUED 4-25-38 NAME OF CABLE HARRISBURG-PITTSBURGH LETTER B
SECTION HARRISBURG-SHIPPENSBURG

CIRCUIT GROUP	TOT CKTS	1	2	3	4	5	6	7	8	9	0	% OF TOT
ATLANTA-PITTSBURGH	5				4							20
ATLANTIC CITY-PITTSBURGH	6	1		3			6					50
BALTIMORE-CHICAGO	5	1	2									40
" -CINCINNATI	2	1										50
" -CUMBERLAND	1				4							25
" -DETROIT	2	1										50
BOSTON-PITTSBURGH	9	1	2	3	4	5	6					67
CANTON-NEW YORK	4				4							25
CHAS. W. VA.-WASHINGTON	5	1		3	4							60
CHICAGO-MIAMI	7									9		14

PART OF A CABLE-SECTION RECORD PAGE. THIS ONE IDENTIFIES THE CIRCUITS IN THE HARRISBURG-PITTSBURGH B CABLE

the present moment, since the rising tide of business is still to come. But the daily morning peak is due in an hour or so. Remedial action must be taken on a dozen fronts right now, to round up all possible circuit capacity for rerouting traffic and replacing circuits. The Plant Department can be depended upon for an early and definite report on spare circuits available in the partially-damaged A cable. In the meantime there's effective action to be taken. . . . Ask Plant to postpone certain scheduled testing operations, as some of these circuits may be needed . . . Request the operating room to connect some groups to "busy registers" for a measurement of circuit loads. . . . A telephone conference with local operating com-

pany men at Harrisburg and Pittsburgh to get agreement on the first relief measures. . . .

NY TO ATLA

PLS ADV. PLANT TO EXPECT HEAVY PATCH LOAD.

MAC

OK ATLA

As preliminary mobilization goes ahead, we begin to understand the significance of the Bureau's activities. Somehow we are reminded of the fire warden in his high tower overlooking valuable forest areas. He, too, would understand about eternal vigilance and resourceful action in a job where "Protection" literally is a watch-word. The circuit layout is so well integrated that this line interruption in Pennsylvania will be felt in a hundred cities from coast to coast, because it affects some of the lengthiest and busiest long distance lines in the country. The network is closely knit, complex. But it also is built for *flexibility*, permitting almost endless combinations. In this particular case, facilities lying far away, within the

CGO TO NY

READY ANYTIME FOR CONF.

EFB

OK NY REW

jurisdiction of the Cleveland and Chicago Bureaus, are involved. Presently they are being discussed in a three-way telephone conference. Constructive thinking, long experience, coöperative spirit—all these factors are in evidence.

". . . Now, Chicago, let's talk about the groups terminating in your area. We have only three Philadelphia-Pittsburgh through circuits working out of ten. We'd better get five more in there right away. Where could you meet us?"

"Well, Washington-Pittsburgh has fifteen circuits. Let's take four out of there and one through Newark."

"Good! Hello, Cleveland. On Pittsburgh-New York we're short sixteen out of twenty-four. We can meet you at Albany, Newark, Balt- . . . ."

"Make it five out of Baltimore?"

"Fine, Cleveland, we'll order. Let's look at Indianapolis-New York; also Chicago-Los Angeles and other Coast points. . . ."

"Yes, surely. . . ."

". . . And let's turn up the Chicago-New York reserve circuits that are not in the B cable. Then we can . . . ."

. . . "Good idea—do you agree, New York?" . . .

From such fragments of shop-talk we gather that restoration plans are fast taking shape. Simultaneously, other workers in the three Bureaus are engaged in similar telephone contacts with their own Plant, Engineering, and Traffic forces, along with local operating companies of the Bell System in all directions. Teletypewriter messages zip back and forth between scattered offices having a stake in the situation. Bureau supervisors select the circuits most adaptable to the needs of the moment; then decide where and how the lines should be assigned. Patch orders, giving details on these rearrangements, constitute a stream of instructions flowing to the testboards for execution.

NY TO CLEV

PO 12939 NO. 65 NY-PITB THRU RICH.

VCW

OK CLEV REB

Scarcely an hour has passed since the cable failure struck. But telephone minds from points half the country over have "looked at" the scene of the trouble. They have agreed on temporary restoration moves, shared the required facilities from their areas. Mr. and Mrs. Public, meanwhile, have been putting through more and more calls every minute, as per daily

habit. And, without suspecting the fact, in many cases these "travelers" have been widely detoured on the way to their telephone destinations.

A.T.&T.CO. L.L.DEPT.

TRAFFIC CONTROL ORDER. NO. 12939

FORM T357 6-38

GROUP AND CIRCUIT NO. 65 NY-Pitb

CONCURRENCE RECEIVED FROM BOM & FA

	CIRCUITS IN GROUP		USAGE DATA *		
	* AUTHORIZED	** IN SERVICE	DATE TAKEN	% BUSY	USED MINUTES
THROUGH	14	11			
TERM AND COMMON	24	7			
COMBINED					

* INCLUDE CIRCUITS ESTABLISHED BY TRAFFIC CONTROL ORDER IF FORM T-393 HAS BEEN FORWARDED.

** INCLUDE ONLY CIRCUITS ACTUALLY WORKING AT THE TIME THIS ORDER IS ISSUED.

FACILITIES USED		
FROM	TO	FACILITY
NY	Rich	#4
Rich.	Pitb	#1

1938	TEST BOARD	DATE	TIME	INITIALS PLANT	INITIALS TRAFFIC
CIRCUIT ORDERED	NY	11/29	9:20A	RJ	WCM
"					
"					
REPORTED IN SVC					
ORDERED DISCONTINUED					
DISCONTINUED					
CANCELED					
SUPERSEDED					

CLASSIFICATION	ACCOUNT INCREASED TRAFFIC	ACCOUNT CIRCUITS OD	ACCOUNT CIRCUITS RELEASED	OTHER REASONS (EXPLAIN)
CIRCUIT PATCHED		✓		
CIRCUIT TURNED UP				

REASON FOR ISSUING THIS ORDER: Cable Trouble - Hbg-Shipp "A" & "B"

REMARKS

FORM T393 FORWARDED _____ 193__

OVER

A Traffic Control Order to the Testboard: An Important Step in the Process of Building Up a Re-route

In the midst of it all, the Control Bureaus have found time to handle special problems incidental to the failure. A distant call for quick help in replacing a circuit scheduled soon to carry a radio program. . . . An operator requesting a new circuit routing on a subscriber's urgent call to an out-of-the-way point. . . . Line up extra facilities expected to be needed for the next three days after the Atlantic Fleet puts in at Norfolk tomorrow. . . .

In short, although it is only a few minutes past 10 A.M., the hole torn in the country's communications pattern already has been carefully rewoven to such an extent that no serious delays to service have as yet resulted. Replacements and temporary rerouting have just about kept even with demand. Can the

balance be maintained? Chances are fairly good, judging from the additional details now being telephoned by the Plant Department concerning the break itself. . . .

"This trouble was caused by a truck overturning, catching fire and burning sheath and all insulation from the B—plus two or three feet of sheath in spots, and some insulation, on the A. Gangs and material are moving in from both sides of the break, that is, from Harrisburg and Shippensburg. They left at 9:30, and will get to the trouble about 10:30. We've checked and find we can make 20 or 25 circuits good with spares, if you'll tell us what you want."

"All right! We'll fix up a list and give it to Harrisburg. And are there any prospects for restoration yet?"

"Not yet. But I'll have someone call you."

NY TO CLEV AND CGO

HAVE 25 SPARES WILL MAKE CKTS FROM PITB EAST IF YOU AGREE.

CWH

OK CLEV

OK CGO

The spare circuits are set up as promised and the Bureaus assign them to sections as needed, based on incoming information as to traffic conditions at various points. For the problem now is to keep watch in all directions to make sure that different areas are getting a fair share of the available facilities. The hour hand barely reaches 11 A.M. when another Plant report brings encouraging news. . . .

"Just wanted to let you know that the gang's on the job, running in twisted pair. Circuits will be coming up about 20 an hour, I hope. But it's pretty cold out there on the line —down around zero with a high wind. That may slow 'em up some. We *might* finish up by 5 P.M. But with the weather tough as it is, better figure on 6:30 or 7 o'clock. . . ."

Control makes quick use of this information. Teletype flashes it to the other Bureaus. Telephones speed it across the map to other waiting offices whose shortened facilities are beginning to feel the pressure of traffic as the day wears on. "Circuits will be coming back at the rate of 20 an hour."

NY TO CGO AND CLEV

CKTS ON TWIST WILL COME UP 20 AN HOUR STARTING IN FEW MINS. HAVE GIVEN LIST TO PLANT FOR FIRST LOT. IT INCLUDES REST OF OD CKTS EAST OF PITB AND NY-CGO. ADV. IF NOT OK.

AEE

OK CGO

OK CLEV

Every office is ready with its answer: . . . "The circuits we need first are Nos. 7, 8, 9 Philadelphia-Pittsburgh; 54, 55, 57 New York-Pittsburgh . . . 4, 5, 6 to Boston . . . Dallas, Seattle, Reno. . . ."

The clock ticks swiftly on. Circuits keep coming back through the repair crew's efforts, together with further rearrangements of the normal network whenever and wherever possible. The Control Bureaus continue their panoramic watch over the layout, anticipating congested points, asking questions, making suggestions. The combined thinking and action of 42 telephone offices in as many different cities is being coördinated in the attempt to save long distance users from undue inconvenience or disappointment.

How has the attempt fared? We get some idea by listening in on the New York Bureau's 2 P.M. report to the General Traffic Manager:

". . . I believe the reports I've been giving you have covered the general progress of things, but I wanted to assure you that the current replacements apparently have met service

needs. Out of the 156 circuits in trouble, 124 have been made good one way or another. With most of the busy hours behind us, except a few western points, there won't be much of any problem. . . ."

NY TO BOS AND PHLA

CANCEL ALL EMERG ROUTES AND RETURN TO NORMAL ROUTES.

REW

OK BOS

OK PHLA

The emergency has been met. All hands may now return to routine things that . . . But wait. We learn that the work just done must now be undone. That is to say, the Control Bureaus have the responsibility of getting the layout "regular," or back to normal. This means retracing the telephone and teletype trail that was blazed around the country during the past five or six hours. . . . Examining conditions anew. . . . Taking down the patched layout stitch by stitch, carefully timing each move to protect current service needs. . . . Ordering circuits placed back on their normal beats in readiness for evening busy hours. . . . Turning back to Plant the long copper threads required in the resumption of testing work. . . .

NY TO CLEV

ALL EMERG ROUTES INTO EASTERN AREA MAY NOW BE CANC.

C W H

OK CLEV ELP

Progress toward normal is faithfully reflected on the big display boards in the three Control Bureaus. Previously studded with plugs of white, orange, green, and blue, meaning

"cloudy," the boards now are almost clear, meaning just that. The clock registers 6 P.M., and it finally is safe to consider the emergency conquered. The sun sets upon another day—another day during which the country's long distance service varied little from the standard expected of it.

NY TO CGO AND CLEV

HAVE AGREED WITH NY TB TO TAKE DOWN

RESERVE CKTS AT THEIR CONVENIENCE.

CWH

OK CGO

OK CLEV

Tomorrow? The events of today may be repeated—in greater or lesser degree—involving some other troubled point in the network. Potential hazards from man and Nature are many, along communications strands whose total length would be sufficient to build 1,000 separate lines around the earth at the equator.

Should tomorrow bring no line interruptions anywhere, Control System people will not lack for practice in their specialty. The day-to-day job involves many things. There are frequent cases where the business offered will overrun contemplated circuit loads unless relief is provided. During normal periods of circuit loading, hundreds of such instances arise each month.

Arrangements must be made for the release of circuits to the Engineering as well as Plant Departments for testing and maintenance work, in such amounts and at such times as will make it possible to do these jobs in the most economical way. Here, too, hundreds of circuits are concerned each month, frequently involving replacements of many of the circuits so released.

An intimate knowledge of circuit group performance also is useful for other purposes. For instance, frequent reference of

such information to the Traffic Circuit Engineer is invaluable to him in determining future circuit requirements.

To Argus, if he remained to witness the day's cable-break events with us, a last and frankly prideful word. The worst possible traffic jam in history has never happened. It will occur at that inconceivable instant when Control personnel, together with all the others, are bereft of their present proclivities for *keeping an eye on everything*.

Mount Olympus papers please copy.

H. D. HOCKER

The Geography of the Bell Telephone Laboratories

A SMALL frame building—a forest of stub poles—a telephone central office—a box and balcony on a pole—an automobile trailer—these are some of the places where Bell Laboratories engineers carry on their development work. For "463 West Street," famous address among communications men, houses only a part of the Laboratories' activity. Across the street is its Vacuum Tube Laboratory; and in modern loft buildings nearby are other laboratories and offices. These furnish space for such activities as can be carried on in urban surroundings. But dust storms occur in the Middle West; to study the static interference they produce, engineers must go to Texas. Sleet may appear anywhere, but no one knows when; engineers from the Laboratories installed automatic measuring apparatus at several likely spots and left it. Short-wave radio channels, now the backbone of transoceanic telephony, first had to be studied extensively; their wide-spread antennas were installed in New Jersey farmland remote from sources of interference.

Some of these Laboratories outposts have made communications history. There was the shack at Montauk, Long Island, from which the Bell System's first radio transmissions were made in 1915. There was a similar house at Arlington, Virginia, whence the first transoceanic radio telephone tests were made that same year. There was the "Market" telephone building in Newark, where the first power-driven switching system was installed in 1914, and the telephone building in Omaha where the first panel system was cut over in 1921. Even at Gulfport, where thousands of treated pole samples live

their lives in obscurity, history of wood preservatives is being made.

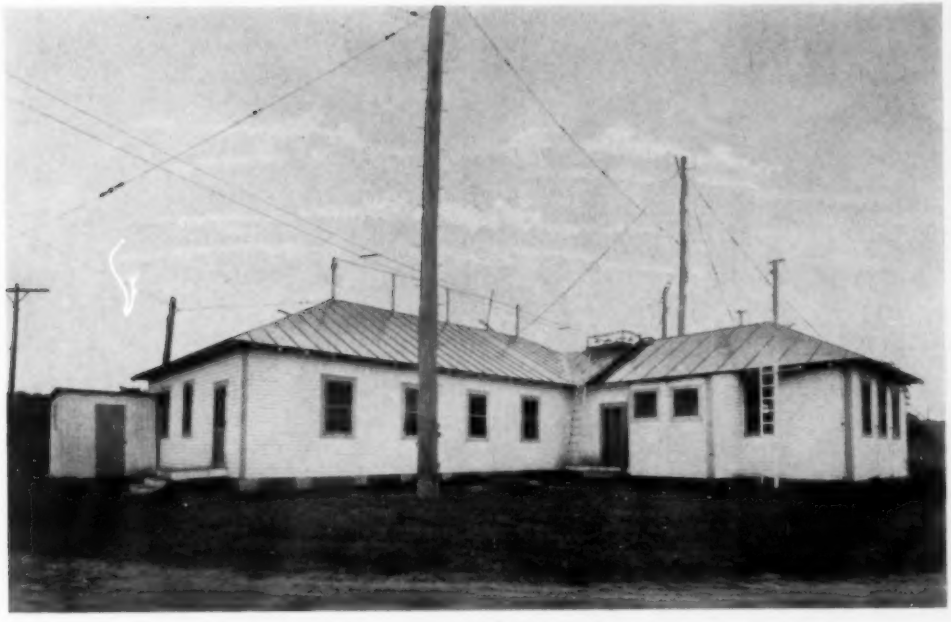
When Bell Telephone Laboratories began operations in 1925, it took over from its predecessor, the Engineering Department of the Western Electric Company, a field laboratory at Deal, New Jersey, where work had been done on ship-to-shore radio telephony. Four years later, additional land was purchased, bringing the acreage up to 208, and facilities for studies of radio transmission were greatly augmented. Also in 1929 a tract of land at Holmdel, New Jersey, was purchased for a radio reception laboratory which replaced a smaller tract at Cliffwood, used from 1919 to 1930.

At the Deal and Holmdel Laboratories, the Radio Research Department is now conducting experiments and tests of short-wave radio transmission and reception; it is designing and developing apparatus and methods intended to improve radio-telephone services of the Bell System. The so-called "Musa" antenna system, which selects a particular beam of incoming radio waves, was evolved at Holmdel. Testing in connection with short-wave transatlantic transmitter development is done at Deal.

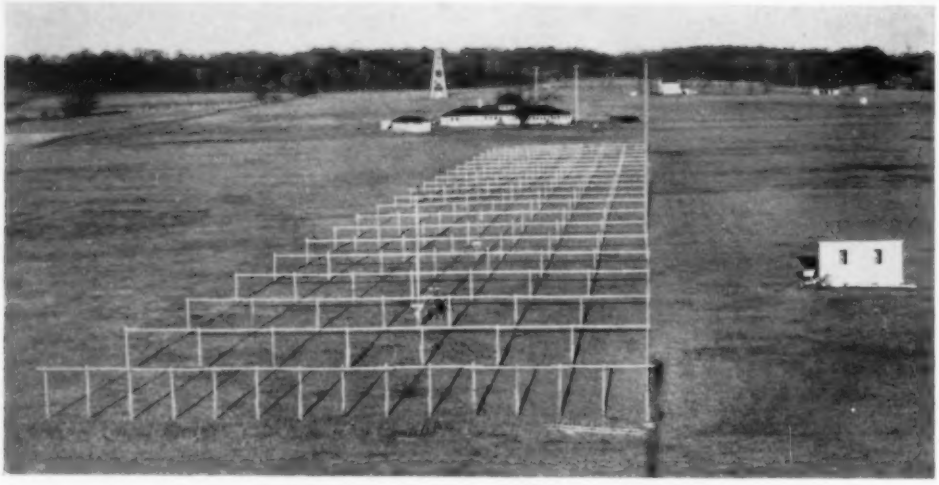
The transmission of electric waves at extremely high frequencies, with wavelengths in the order of 10 cm. through rods of dielectric material and through metal tubes, without the usual return conductor, was predicted mathematically many years ago. Experiments that have been made with electric wave guides have confirmed this theory. Since 1931 wave guide research has been carried on at Holmdel. These wave guides offer the possibility of transmitting very wide frequency bands, and consequently extremely large numbers of speech channels.

Holmdel was recently the selected site when the Physical Research Department wanted to make certain acoustic tests under conditions approaching ideal free sound wave propaga-

THE RADIO RESEARCH LABORATORY AT DEAL, WHERE INVESTIGATIONS IN SHIP-TO-SHORE AND TRANSOCEANIC COMMUNICATION ARE CARRIED ON



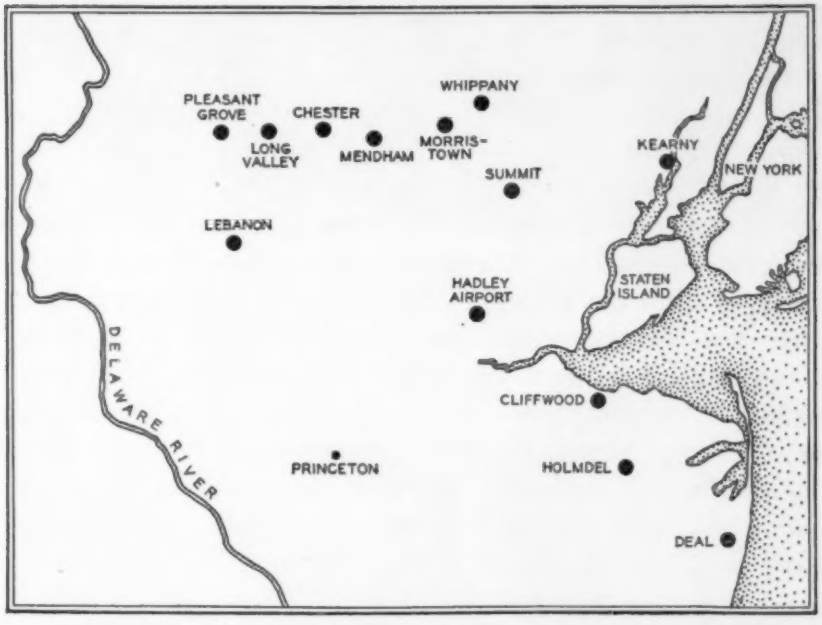
THE SHORT-WAVE RADIO LABORATORY AT DEAL



An Artificial Ground System at the Holmdel Radio Laboratory

The Tandem Group of Six Rhombic Antennas of the Experimental "Musa" System at Holmdel

tion. A wide open space was required. For the experiment a small sound source was placed at the center of a 100 ft. square concrete platform. This resulted in a progressive hemispherical wave which was used to make measurements of the directional characteristics of sound perception of the human ear and also to study certain diffraction problems related to microphone baffles.



Locations of Activities Carried on in New Jersey by the Bell Telephone Laboratories

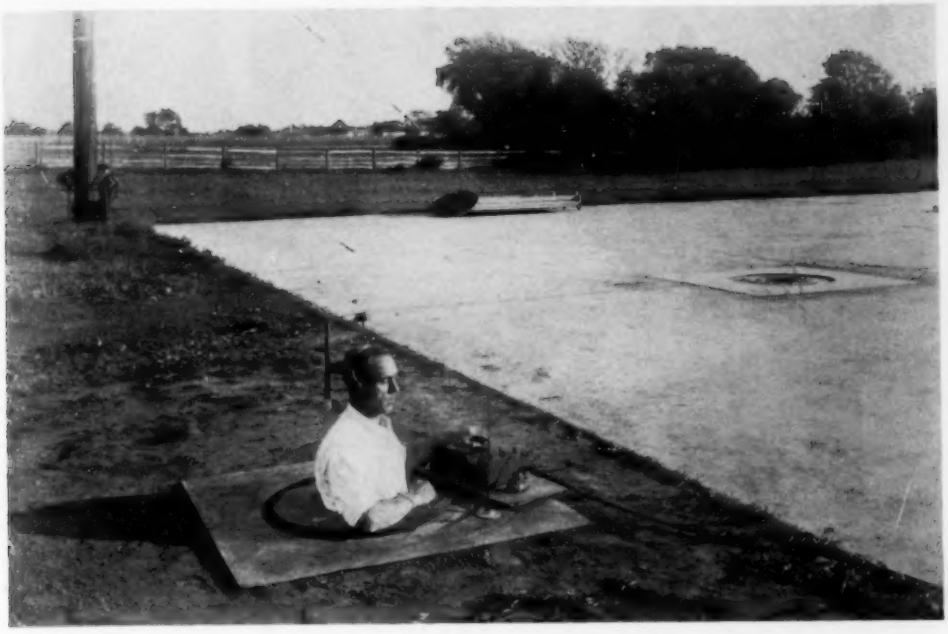
Whippany and Mendham Laboratories

With the advent of high-power broadcasting it was necessary to have a field laboratory that could conveniently be used as an extension of the Radio Development Department in New York and which would still be sufficiently out in the country to avoid disturbing any large group of listeners. Such a site was obtained in 1926 at Whippany, New Jersey, and was used for the development of a 50-kilowatt broadcast trans-

mitter. There are probably many readers who remember listening to this powerful transmitter, known as "3XN," which was heard throughout the country during test periods after midnight. Upon the completion of this work, other high-power developments became necessary, so that further expansion to the property was made in 1931 with the addition of 75 acres of adjacent property, which brought the total to 122 acres. (See Frontispiece.) Previous to this the north and south wings of the main laboratory were reconstructed to care for the development of apparatus for aircraft radio, common frequency broadcasting, and long-wave transoceanic radio projects. Meanwhile this laboratory was used so constantly for transmitter work that it was necessary in 1930 to find a new location for field strength measurements and for radio receiver developments. The location desired was one sufficiently removed from the Whippany laboratory to avoid interference from tests on transmitters and yet close enough to facilitate transportation between the two of engineers and equipment employed at both places. Such a place was found about ten miles away at Mendham where, for the past seven years, studies have been conducted in broadcast receivers, and communication equipment for aircraft, police and marine service, field strength measurements, precision frequency-measuring apparatus, and radio interference.

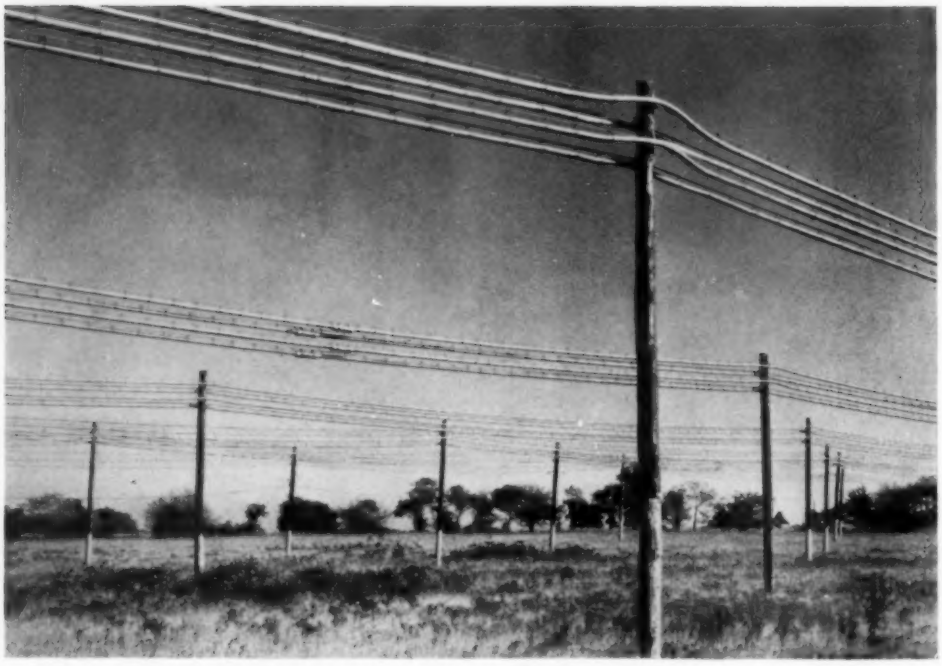
As part of the broad study of radio communication between ground and aircraft, two airplanes are used as flying laboratories. These planes are based at Hadley field, a relatively short distance from the Whippany and Mendham laboratories, in a hangar leased for the purpose which also provides adequate ground laboratory space. Among the more recent work that has been done, in addition to the development of aircraft transmitting and receiving equipment, are the terrain clearance indicator and the airplane locator.

The Whippany laboratory has also been used for tests other



AN EXPERIMENT IN ACOUSTICS AT HOLMDEL IN WHICH SOUND WAVES WERE STUDIED UNDER CONDITIONS ELIMINATING WALL REFLECTIONS

ONE OF THE RESONANT CHAMBERS USED FOR TESTS OF WAVE-GUIDE TRANSMISSION. TWO OF THE EXPERIMENTAL LINES APPEAR IN THE PICTURE



One of the Aerial Cable Tests at the Field Laboratory at Chester, N. J.

One of the Test Houses at the Chester Laboratory

Taking a Motion Picture at Chester to Show the Making and Applying of Mortar Bandage Joints to Multiple-duct Conduit

than radio. Several years ago response measurements were made on high-power loud speakers. One group of speakers had a sound-power output of 100 watts, and another group 500 watts. At another time experiments to determine the flammability of central office wiring were made. A small fireproof temporary building was erected for this purpose. Regular dial-office frames were used, some wired with standard cable and others with improved types of cable. Careful observations were then made, under fire conditions, of relative flammability. In connection with these studies, tests were also made on the effectiveness of various types of fire-fighting equipment for use in central offices.

Outside Plant Development Laboratory at Chester

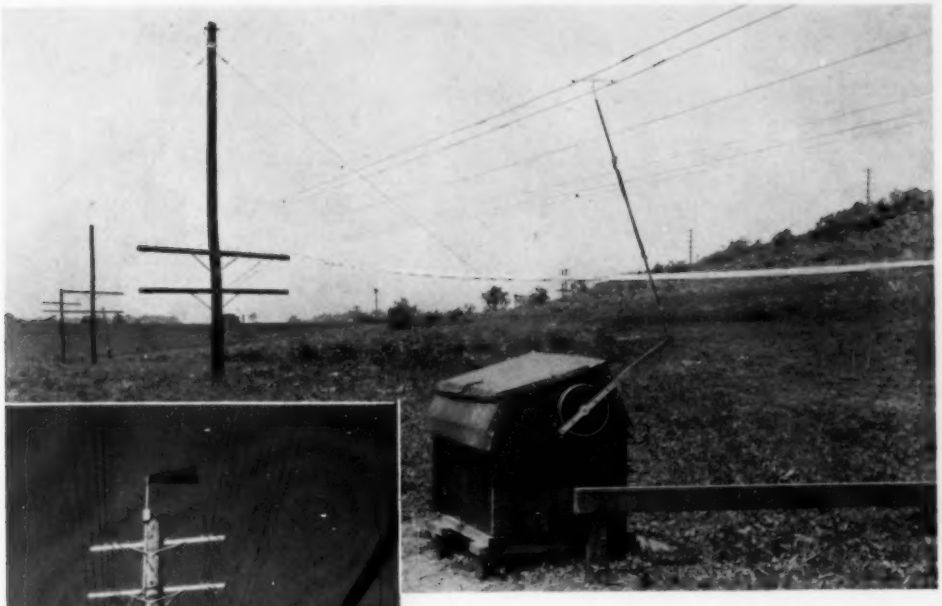
Many of the products used out-of-doors in the telephone plant are of a character which renders impractable their complete development in a city laboratory. Moreover, the development of such products in the actual operating plant and on the rights-of-way of the Bell System would involve difficulties, delays and inconvenience both to the operating companies and to the Laboratories. To provide facilities for such work, a fifteen-acre plot was leased in 1928 near Chester, New Jersey. This proved to be inadequate for certain test purposes not originally contemplated, so that eighty-five acres of adjacent property were purchased in 1930. One important study here was that of contacts between adjacent line wires when they swing in the wind. The closer the spacing, the less noise is picked up, particularly at the high frequencies of the new Type J carrier system. However, contacts between wires produce noise in telephone circuits and false signals in telegraph circuits. Experiments confirmed the practicability of decreasing the spacing between wires of a pair from twelve inches to eight inches, or in some cases to even less. Another investigation was the effect of sway on aerial telephone cables.

Here was developed the plow for placing rubber-covered wire directly in the ground. Extensive tests of various guy anchors have resulted in the specification of an improved form. The "mortar bandage conduit joint," the most effective method yet devised for excluding silt from the joints of vitrified clay conduits for underground cables, was developed at the Chester laboratory.

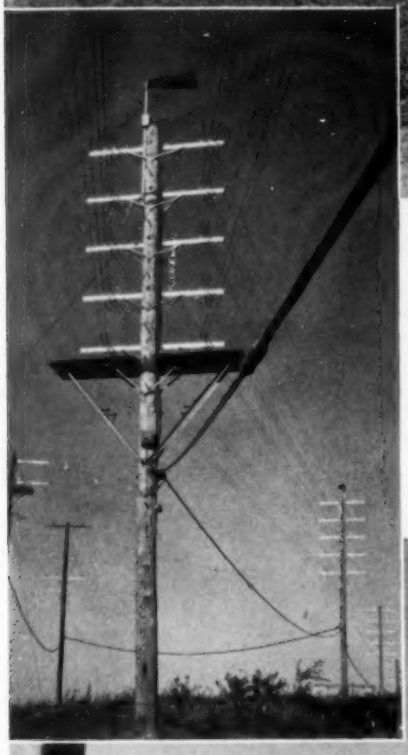
Test plot studies of timber preservatives mentioned above were started by the Laboratories in 1925 at Gulfport, Mississippi, where specimens of treated and untreated wood are planted in the ground from time to time. A similar test plot was placed in operation at Limon, Colorado, in 1929, followed by one at Chester the next year. These three locations represent widely varying conditions: Gulfport, high rainfall and humidity and a long growing season, factors very favorable to decay and insect attack; Limon, low rainfall and humidity and a much shorter growing period, conditions making decay much less rapid; and Chester, where conditions are between the accelerated rate of decay at Gulfport and the slower rate at Limon. All three locations have demonstrated their practical value in connection with the selection of suitable preservatives and economical methods of prolonging the life of poles.

Laboratories at Hawthorne, Kearny and Point Breeze

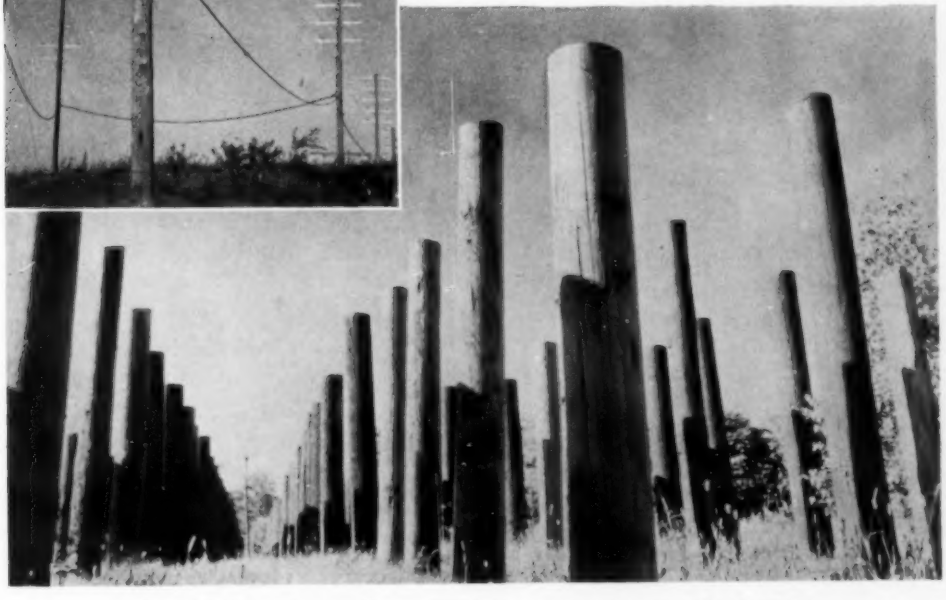
Most of the laboratories development work on lead-covered cable has been carried on in the plants of the Western Electric Company at Hawthorne, Kearny, and Point Breeze, as the cost of the required equipment makes it impracticable to build cable structures in the Laboratories. For many years the group at Hawthorne carried on all this work, but gradually the development of exchange-area cable has been transferred to Kearny and the development of toll cable to Point Breeze. The Hawthorne cable laboratory was discontinued last November.



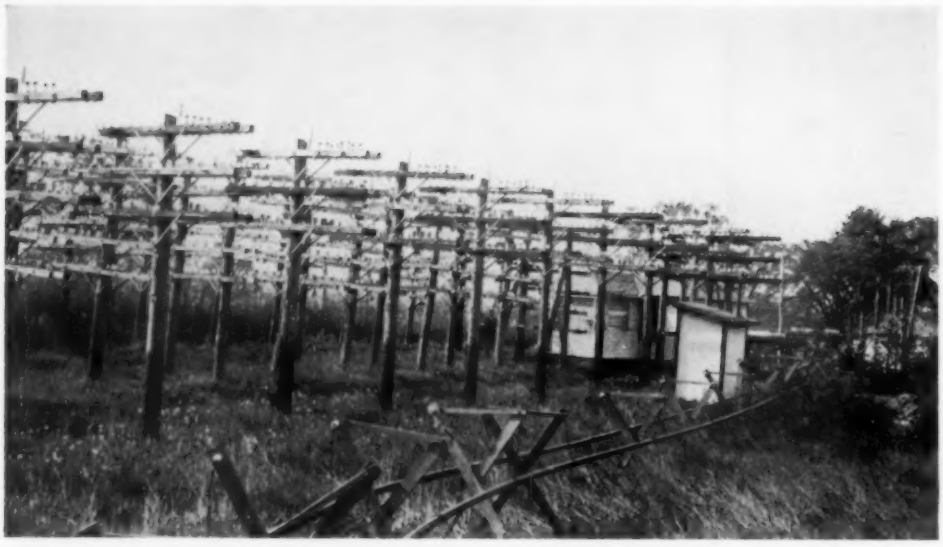
This Device Tests Line-wire Ties and Insulators to Determine the Effect of Swinging



An Experimental Pole Line at Chester for Studying the Effects of Wind on Open-wire Lines



A Test Plantation of Telephone Poles at the Chester Laboratory



VARIOUS TYPES OF INSULATORS UNDERGOING FIELD TESTS AT PHOENIXVILLE, PA. IN THE FOREGROUND IS AN EXPERIMENTAL CO-AXIAL CONDUCTOR LINE

CO-AXIAL CONDUCTORS ENTERING THE TEST HOUSE AT PHOENIXVILLE. HERE WERE CONDUCTED THE FIRST TESTS OF THIS STRUCTURE AS A MEDIUM FOR LONG-DISTANCE TRANSMISSION OF A BROAD BAND OF FREQUENCIES

Chemical Laboratory at Summit

For nearly ten years certain groups of the Chemical Laboratories have occupied a three-story building at Summit, New Jersey. Here studies are made on non-rubber insulation, ceramics, dielectric materials, wood preservation, and certain electro-chemical problems. The rotting of wood is caused exclusively by fungi which feed on it. To retard decay the wood is impregnated with fungicides—creosotes, for example. The toxicity of fungicides is studied at the Summit laboratory by cultivating fungi in bottles and determining the effects of different fungicides on them.

Cable sheath is one of the largest single uses of metallic lead, and the Bell System alone has about 180,000 miles of lead cable, of which about 40 per cent is underground. To minimize the damage from corrosion, studies are made at Summit on the behavior of lead and lead alloys when subjected to various corrosive agents.

Millions of relays, wound with fine copper wire, are used in telephone offices. Corrosion can work havoc with the windings, if atmospheric moisture is allowed to penetrate the insulation. Accordingly, chemists at Summit are constantly studying materials for wrappings to keep the moisture out and wire-insulations that will withstand what moisture gets in.

Transmission Studies

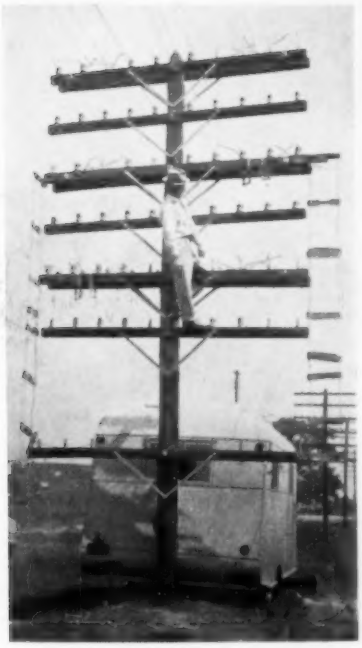
There are also certain field stations where transmission tests have been carried on for a number of years. Oldest of these is the test station near Phoenixville, Pa. Crosstalk tests were begun here in 1919 by adapting an eight-mile section of an abandoned open-wire line. The location has been in practically continuous use ever since, principally as a proving ground for methods of transposing open-wire lines for high frequencies. One of these investigations showed the importance of close spacing between the wires of an open-wire pair

in order to reduce high-frequency crosstalk; the practicability was proved at Chester, as has been said.

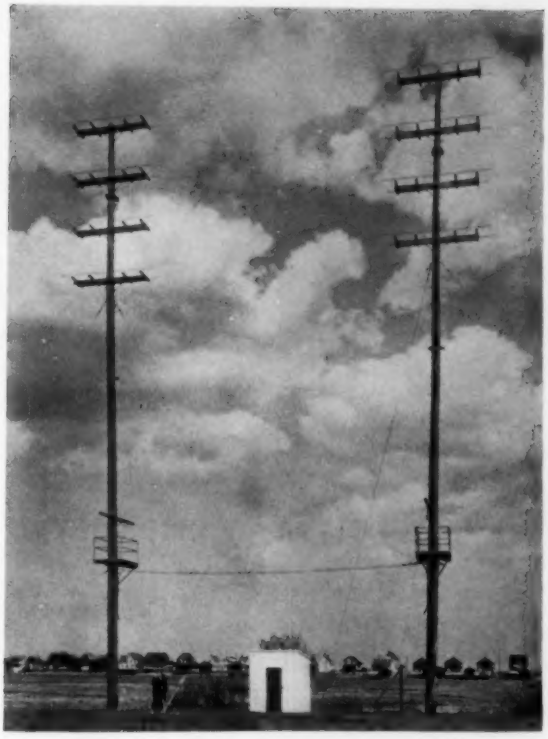
It was at Phoenixville in 1929 that a coaxial conductor line was built, on which were conducted the first tests of this structure as a medium for the long distance transmission of a broad band of frequencies. Considerable study has been made also at Phoenixville of the performance of open-wire insulators at carrier frequencies. At present a study is being made of the transmission properties of open-wire lines for high frequencies.

In addition to these locations, which may be considered as permanent sites, the Laboratories employs from time to time a great variety of temporary quarters; many of them are in central office buildings of Bell System operating companies. For example, at Morristown, N. J., the art of carrier telephony over toll cables came into being. A new toll cable only a few miles long was placed on the route extending west from that point and was equipped with carrier apparatus installed in the local central office. In 1931 satisfactory two-way conversations were held over a cable carrier circuit looped back and forth over different pairs; it was more than 7500 miles long, and had a total attenuation of about 12,000 db. Subsequently, buildings were erected at Pleasant Grove and Long Valley to house cable-carrier repeaters. At these locations tests were made on repeater stations designed to be left for considerable periods of time without attendance. Also, in order to test the possibility of neutralizing or balancing out cable crosstalk by introducing a compensating unbalance at one point in a repeater section, a small building was constructed near Mendham, N. J., to house assemblies of balancing coils and condensers. Subsequently, several of these new type-K systems were installed in anticipation of later need for commercial service between Toledo, Ohio, and South Bend, Indiana, and all parts subjected to complete tests.

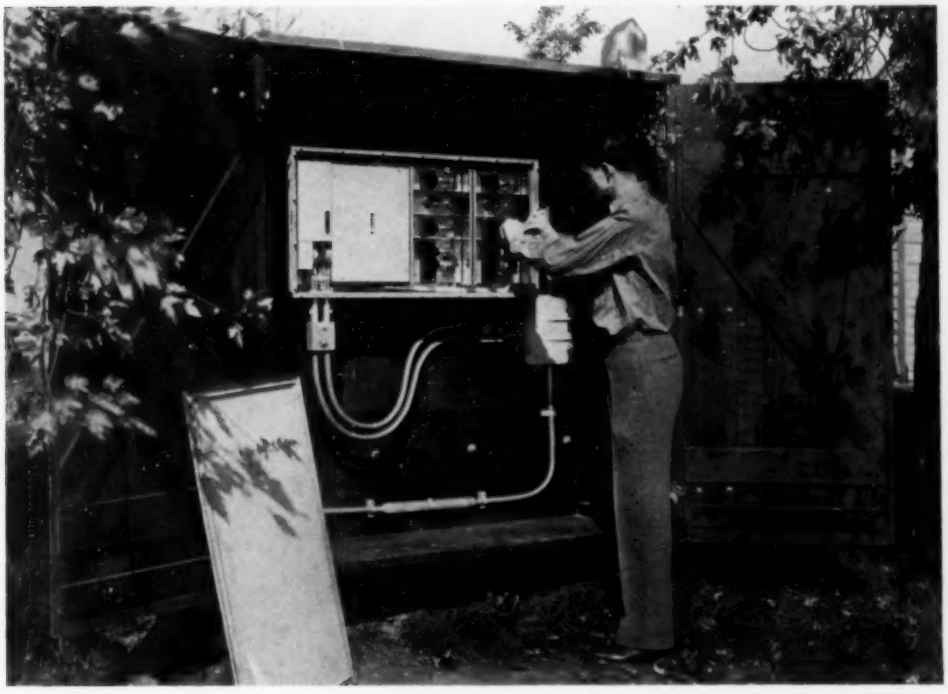
Tests are now being made, at Morristown and vicinity, of



Trailer in Use at Edgewood, Tex., for Measurements of Open-wire Crosstalk



Ultra-short-wave Antenna for Radiotelephone Experiments between Green Harbor and Provincetown, Mass.



Preparing for a Test of the Experimental Co-axial Cable Installed between New York and Philadelphia. This Above-ground Repeater Station Is Near Dunellen, N. J.

THE CHEMICAL LABORATORY AT SUMMIT, N. J.

TESTING WOOD PRESERVATIVES, USING A SPECIAL TECHNIQUE DEVELOPED AT THE SUMMIT LABORATORY

THE BUILDING AT PLEASANT GROVE, N. J., WHERE TESTS OF CABLE-CARRIER REPEATERS WERE CONDUCTED

the effectiveness and stability of crosstalk balancing, of transmitting over cable pairs the power supply for auxiliary repeaters, and of methods of stabilizing the attenuation of cable circuits.

It is sometimes practicable to use the telephone plant itself for experimental work. For example, when the new type-J carrier telephone system was being designed, a 100-mile section of open-wire line in Kansas was re-transposed by the telephone company and a traveling laboratory was set up in a trailer. Crosstalk and noise measurements were made at various points along the line and the data obtained were used as a basis for further modifications in the transposition design. The first of these systems was installed between Jacksonville and West Palm Beach well in advance of its need for commercial service and exhaustive tests were made on every part of the system. Where dust storms are common, "static" from them is an important factor in these high-frequency systems; a party of Laboratories engineers is now making measurements at Amarillo, Texas.

Perhaps the most extensive of the outlying laboratories, geographically speaking, is that which stretches all the way from New York to Philadelphia. This is the coaxial cable, some 90 miles long, which has two attended repeater stations, and seven unattended stations installed in manholes or in wooden boxes along the route. Tests of multi-channel telephone and television-signal transmission were made in the Fall of 1937 over this cable, using frequencies up to about one million cycles. Similar measurements employing still higher frequencies are now in progress. Special forms of coaxial conductor have been hung on a five-mile stretch of pole line ending at the Princeton repeater station; testing apparatus has been installed there by the Laboratories.

Engineering tests in the field are also made by the Systems Development Department, to assure themselves that a system

which is workable by engineers in the laboratory is also workable by telephone operators and by the public. These field tests also show how the proposed system will work in heavy traffic, and how well it coördinates with existing designs. After corrections have been made and the first system has been manufactured and installed, it is subject to further tests under Laboratories supervision. Instances of such trials are those of the crossbar system at the new Troy Avenue office in Brooklyn, and the Murray Hill 6-office in Manhattan. Thus is made certain that the new system will enhance the Bell System's reputation for good service at reasonable cost.

R. LINSLEY SHEPHERD

Aids to the Hard of Hearing

MANY of us, who think we have acute hearing, have attempted to carry on face-to-face conversations in noisy locations, only to find that, in spite of our best efforts, much of the conversation must be repeated before a reasonable understanding of the context is obtained.

While it is obvious that, in the above conditions, the difficulty of carrying on a satisfactory conversation is not due to an actual loss of hearing, it is quite similar, between persons having normal hearing, in its temporary effect on the talker and listener. It is an "apparent loss of hearing" due to the masking effect of the loud noises present in the location in which the conversation is attempted. Carrying the analogy a step further, it is evident that if the noise at the location at which the conversation was taking place were predominantly high-pitched (say above about 3000 cycles per second) it would, while being annoying and causing some impairment to the ease of hearing all the speech syllables, have much less effect, since most of the speech sounds to which a person would be listening are below 3000 cycles per second. On the other hand, if the listener were attempting to hear a symphony orchestra, and the notes and overtones from some of the instruments were very high-pitched, it is evident that a high-pitched noise would be distinctly objectionable. This latter phenomenon resembles closely that type of deafness which results in inability to hear effectively certain frequencies while retaining reasonably good hearing at other frequencies.

Much has been written on the subject of deafness by members of the medical profession and by those engaged in scientific research on sound perception. All these agree that there are almost as many conditions and degrees of hearing impair-

ment as there are persons afflicted by it. When one also realizes that several million people in the United States possess, in some degree, impaired hearing, he can readily appreciate that the problem of rendering aid to them is both complex and extensive.

Many generations ago it was realized that it was possible, by means of mechanical devices, to increase the ability of partially deaf people to hear many of the sounds necessary in their day-by-day social intercourse. A review of the literature on this subject reveals that many various-shaped "hearing trumpets" were devised to direct a greater amount of the sound energy into the ear. Other devices worked on the principle of a mechanical "sounding board" with a fixed arm which could be held against the mastoid bone, between the teeth, or on the forehead. The idea of these latter devices was that vibrations of the bone structure of the head would be imparted to fluid in the cochlea and the nerve endings would thus be stimulated.

There is little doubt that many of these early aids were distinctly helpful to those afflicted with hearing impairment. However, the amount of sound amplification which could be secured, within practicable limitations of size and weight, by mechanical means remained a serious limitation to a successful solution by this method.

As telephone apparatus became more efficient in converting sound energy into electrical energy and back again into sound energy, more and more of those with impaired hearing found that they could often carry on telephone conversations more easily than they could talk with others face-to-face. This naturally suggested the idea of a "portable telephone system" as a hearing aid. It was not until about 1900, however, that an easily portable acousto-electrical system, consisting of a transmitter, receiver and a small dry-cell battery, was made available.

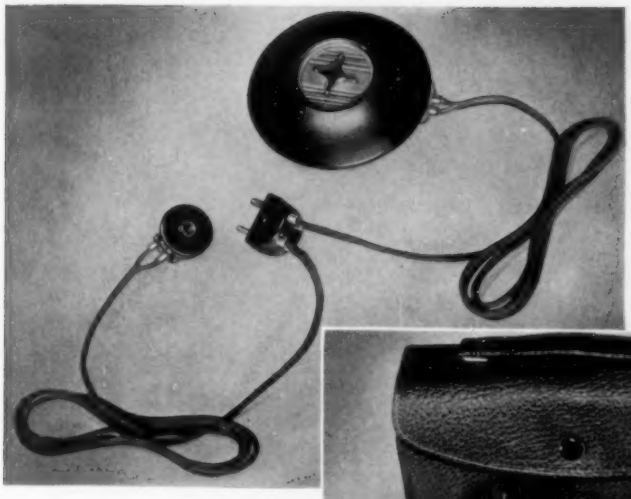


FIG. 1. NON-AMPLIFIER TYPE OF AUDIPHONE, SHOWING AIR-CONDUCTION RECEIVER, PLUG, MICROPHONE, AND CORDS

FIG. 2. AUDIPHONE ARRANGEMENT WITH LEATHER CARRYING CASE HAVING COMPARTMENTS FOR MICROPHONE, AMPLIFIER, BATTERY, AND CORDS. THE LORGNETTE HANDLE, BONE-CONDUCTION RECEIVER, AND AIR-CONDUCTION RECEIVER ARE ALSO SHOWN

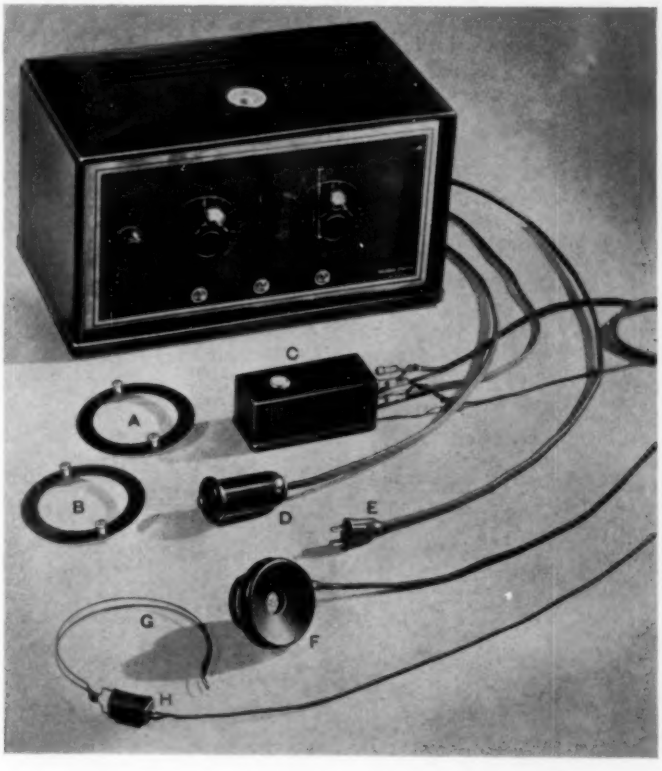


FIG. 4. THE 6A AUDIOMETER, WITH ACCESSORY EQUIPMENT. *A:* 126A AUDIOMETER INDEX RING. *B:* 125A AUDIOMETER INDEX RING. *C:* 100A AUDIOMETER MASKING ATTACHMENT. *D:* SIGNAL SWITCH. *E:* POWER PLUG. *F:* 705A RECEIVER. *G:* 14A HEAD BAND. *H:* 700A RECEIVER

FIG. 5. ARRANGEMENT OF ON-OFF KEY AND VOLUME CONTROL OF 23A AMPLIFIER CONVENIENTLY LOCATED WITH RESPECT TO THE TELEPHONE

FIG. 6. DISTANT TALKING MICROPHONE NOW IN USE WITH THE 23A AMPLIFIER

FIG. 7 (LEFT). THE 15A INDICATOR

FIG. 8 (RIGHT). THE 18A INDICATOR

The Audiphone and the Audiometer

Prominent among the acousto-electrical types of hearing aids is the Audiphone, developed by the Bell Telephone Laboratories and made by the Western Electric Company. The various audiphone arrangements vary from the simple, wearable type utilizing a small transmitter and air-conduction type of receiver equipped with a suitably-shaped ear piece, to the group audiphones used in churches, auditoriums, etc. These latter resemble somewhat the public address systems with which we are all familiar, in that the acoustical pick-up utilizes a microphone the electrical output of which is magnified by a vacuum-tube type amplifier whose output is made available to many people. In the group audiphone system this is accomplished by connecting the amplifier output to many air-conduction or bone-conduction receivers located at various points in the church or auditorium, each receiver being equipped with a control so that the individual needing this aid may adjust the sound output to best suit his needs. The bone-conduction receiver, which may be used with any type of audiphone, is substantially different, in its basic design, from the air-conduction type, but, of course, accomplishes much the same result, in that the electrical speech energy is converted—by means of the variable magnetic field which it creates—into a mechanical movement of a metallic object suitably located within the influence of that variable field. However, instead of the usual telephone diaphragm, the moving part is essentially a "vibrating plate" which is pressed against the head on the mastoid bone, and thus, as mentioned before, brings the necessary stimuli to the auditory nerve.

Figure 1 shows a simple "non-amplifier" type of audiphone, while Figure 2 shows an "amplifier" type of set and also shows both an air and a bone-conduction type of receiver. Several improvements are being developed in the group-type of audi-

phone and on that account illustrations of this apparatus have been omitted from this paper.

Closely associated with hearing aids is the audiometer, which has been found helpful by otologists and others in determining the extent and type of hearing impairment. The audiometer consists essentially of an oscillator whose frequency may be varied by the tester. The output of the oscillator is connected to a high-quality air-conduction receiver which is placed on one ear of the person being examined. A tone (usually of about

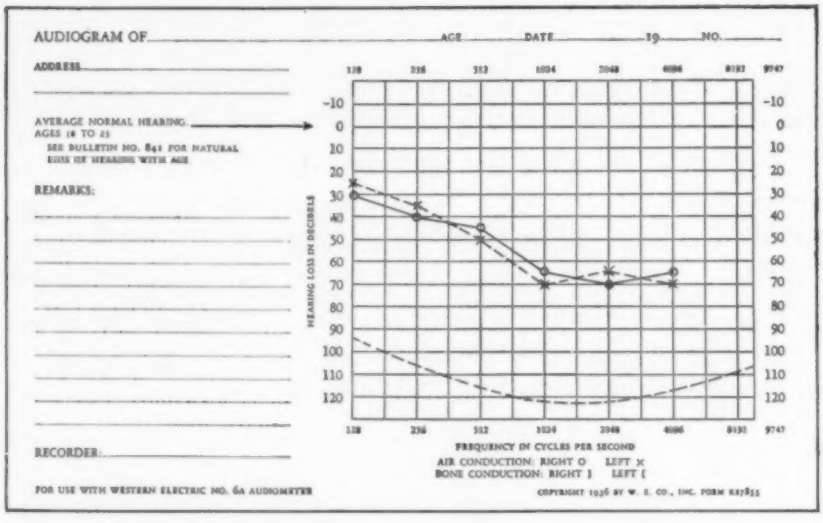


FIG. 3. A SAMPLE AUDIOGRAM FOR THE AIR CONDUCTION RECEIVER

1000 cycles per second frequency) is introduced in the receiver and is adjusted to such an intensity that the person should be able to hear easily—in which case he so indicates to the tester by means of a push-button signal. The intensity of the tone is then gradually reduced until the person fails to signal when the tone is introduced. The sequence of operating the tone is varied (that is, the tone is purposely interrupted) in order to assure that the person is signaling accurately. This process is repeated at several additional frequencies up to about 8000

cycles per second and down to about 100 cycles per second. The other ear is tested in a similar manner.

When using the audiometer for such hearing impairment tests, a part of the measurements also includes the use of a bone-conduction receiver. Since the bone-conduction receiver causes the entire bone structure of the head to vibrate and thus stimulate the nerves associated with both ears, it is necessary to prevent the ear not being tested from introducing an inaccuracy. This is done by placing an air-conduction receiver on the ear not under test and introducing the test tone continuously in that ear. The tone in the bone-conduction receiver back of the ear under test is periodically interrupted in order that the person can more readily determine when the intermittent tone is no longer heard.

A sample air-conduction audiogram taken in this manner is shown in Figure 3. It will be observed that the 0 line on the audiogram is labelled "Average Normal Hearing—Ages 18 to 23." By means of correction factors, the readings can therefore be used to determine whether the hearing loss is likely to have been a natural result of age or is due to other causes.

Figure 4 shows the latest type of Western Electric audiometer (6–A Audiometer*) which is finding increasing use by otologists and others qualified to interpret its findings. Through its use it is possible to determine—

1. What the degree of hearing impairment may be, whether it is confined to one ear or is present to different degrees, in both ears, and
2. Whether the hearing loss is more or less uniform over the frequency range (loss of sensitiveness) or occurs largely in certain portions of the frequency range (hearing distortion).

* The code designations used in this article refer to the latest apparatus types manufactured by the Western Electric Company and available to the public through telephone companies or, in the case of the audiometer and the audiphone, through dealers.

Special Telephone Equipment for Subscribers With Impaired Hearing

While, as mentioned earlier, many people with slight hearing impairment found that conversations were more readily heard when using the telephone than for many conditions of direct conversations, there still remained many persons with more severe impairment, who could not effectively use the telephone. To aid these, a special auxiliary amplifier (23–A Amplifier) for use with a regular telephone was made available in 1925. This amplifier was arranged so that it could, when desired, be introduced into the receiving branch of the telephone set by throwing a key, and the amount of amplification could be varied by means of a dial. The filament and plate voltage for the amplifier was supplied from dry cells, the amplifier being so arranged, of course, that its filament supply was automatically cut off when the telephone set was not in use.

The initial introduction of this hearing aid for use with the telephones of those subscribers desiring it was, however, attended by some technical limitations. Since the amplifier would tend to augment any electrical energy received from the telephone conductors, it would naturally increase any noises coming from the telephone circuit or any room noises picked up by the transmitter. As long as the augmented noises were sufficiently imperceptible to the person with impaired hearing, however, the increased voice energy improved his reception of the incoming conversation. Too high gains of the amplifier might cause "howling," due to the proximity of the receiver to the transmitter, particularly with the earlier types of handsets, and for this reason the use of the amplifier was not originally recommended with this latter type of instrument.

With the advent of the anti-sidetone arrangement, the likelihood of "howling" was practically eliminated and the amplifier is now used with either anti-sidetone desk stands, handsets, or wall sets. During the last few years some of the public

telephone booths at many important locations, such as railroad stations, etc., where a telephone attendant is on duty, have been equipped with these amplifiers. Thus those with impaired hearing may, upon request, have such an amplifier inserted, and make telephone calls which might not otherwise be possible. Figure 5 shows a typical installation of the control key and dial of the amplifier, conveniently located with respect to the telephone.

In a few instances, trials have been made with a 23–A Amplifier and a special bone-conduction receiver having a relatively high impedance, which have suggested that in some cases this arrangement may have advantages for a subscriber whose type of hearing impairment requires nerve stimuli by means of skull vibrations.

Distant-Talking Microphone and 23–A Amplifier

The availability of the special amplifier described above immediately suggested an extension to the usefulness of this hearing aid. In many cases where a person with impaired hearing found it necessary in his business not only to make frequent use of the telephone but also to carry on direct conversations with clients, etc., the need for maximum flexibility in his hearing aid is obvious. The difficulty of effectively hearing telephone conversations having been successfully overcome by the 23–A Amplifier, it is obvious that by suitably switching this apparatus from the telephone circuit to a local microphone, the hearing of direct conversations would be similarly aided.

In order to permit the greatest freedom to the person carrying on a conversation "across the desk" from one using the hearing aid, it becomes desirable to use not only a suitably high-quality microphone but one having sufficient efficiency so that the talker does not need to place his mouth within a few inches of it. The transmitter used with the latest audiphone arrangements provides sufficient acoustical-electrical efficiency

so that when used in conjunction with the 23–A Amplifier the speaker may ordinarily talk within a radius of two or three feet from it with satisfactory results to the listener. This distance of course depends upon the amount of room noise at the location of the microphone. Figure 6 shows a transmitter commonly used with the 23–A Amplifier for this purpose.

Auxiliary Receiver

The use of a small auxiliary receiver which the user may place over one ear, thus having a telephone receiver over each ear, has proved helpful to some who need to use telephones at noisy locations. To some extent this auxiliary receiver is also helpful in relatively quiet locations to those with slightly impaired hearing and for whom the increase in speech sounds afforded by the 23–A Amplifier is not needed.

Signals—Visual and Audible

In addition to providing adequately for hard-of-hearing persons to carry on telephone conversations, it is also equally necessary to let them know when an incoming call is awaiting them. In houses or other locations, various types of bells may be used. In many cases the use of a lower-toned signal (cow gongs or possibly xylophone bars) has been found adequate for persons having keener hearing perception at the low frequencies. In other cases loud-ringing auxiliary bells have been found practicable.

In business offices and the like, the use of the louder-toned bells would usually prove annoying to the other persons located at nearby desks. In some cases, the lower-toned signals have been found adequate, while in other cases visual signals were used. Two general types of visual signals are available, one being used where but one telephone line needs equipping and the other being suitable where it is desired to provide this feature for several lines. Both types of visual signals are used

not only as an aid to those whose hearing does not allow them to readily hear the usual telephone bells but are also used, and to an even greater extent, by those whose hearing is normal. In the latter case, the visual signal provides either (1) for visual indication in locations of relatively high room noise and where the telephone bell might not be readily heard or (2) for suitable indications in offices where several lines may be picked up at each of several desks and where the use of distinctive tones for the bell associated with each line is impracticable or undesirable.

Figure 7 shows the 15–A Indicator or "bee-hive" lamp signal, which is used with a single line, while Figure 8 shows the 18–A Indicator, which is a type useful where two or three lines are to be equipped with distinctively colored lamps. Where more than three lines need equipping, combinations of these indicators may be used, although usually other arrangements are more attractive.

Other Related Items

While considering the various means which have been made available on a commercial basis for hard-of-hearing persons to use the telephone more effectively and also to carry on direct conversations more easily, something should be said regarding the aids which have come into being to help those who have defective speech to the extent of not being able to speak with sufficient volume to be easily heard over the telephone. The introduction of new types of transmitters (such as 625–A) for telephone sets, provides some degree of benefits for those whose speech volume is somewhat subnormal. Further aid for such cases can be secured through special speech-input equipment which may be individually engineered for the case.

The experts on sound perception in the Bell System have in many cases coöperated with various outside organizations, including members of the medical profession, on matters dealing

with the vocal and hearing organs. The ortho-technic audiphone recently developed is an outstanding example of the great progress made by this coöperative approach to the matter of aiding the hard-of-hearing. This new technique is being extended to the group type of audiphone. Changes are also contemplated in the special station equipment (23–A Amplifier) which should make it more attractive for the hard-of-hearing. It is safe to say that other material benefits to those so afflicted will accrue from the continued research efforts. While those in the Bell System can rightfully be proud of the helping hand which has been reached out to those with impaired hearing, there is no thought that the job is done and no tendency to be satisfied with past accomplishments.

R. F. DAVIS

Directory Paper Purchasing

WHEN you pick up the Manhattan directory of the New York Telephone Company to-day and thumb its 1100 pages, it seems almost impossible that the first New York directory, issued in the Fall of 1878, consisted of one page of book paper on which were listed only 271 names.

Not one telephone number nor a single exchange was printed upon that first directory. Neither were individual names or firms arranged alphabetically. They were grouped by trades, thus: auctioneers, banks, bankers and brokers, bonded and storage warehouses, burglar alarms, clothiers, and so on. You asked not for a number but for a person or a firm, and the boy operator, in due time, connected you.

The communication art was still in its swaddling clothes when that single-sheet directory made its appearance. During the intervening half-century, enormous progress has been made. The habits of a nation have been changed. There are now more than 19,600,000 telephones in this country and their use is almost as natural to the American public as is breathing.

With the growth of the telephone there came naturally the growth of telephone books and, by the same token, a great increase in the amount of paper consumed in printing the directories. So rapidly, indeed, did directories increase in size that paper and printing problems developed almost hand in hand with operating ones. That first Manhattan strip, for example, had by August, 1879, grown into a book-type directory of 48 pages. Five months later, the "book" contained 82 pages, 42 of them alphabetical listings and 40 of them "Business Classifications." A year later, a directory of 150 pages was brought out. In it was made the startling announcement that "Subscribers will, in future, be known to our opera-

tors only by Central Office name and subscriber's number and not by subscriber's name."

In 1890, the page size was increased and yet the listings covered 414 pages. A short time later, pages were again enlarged and two columns of listings appeared on each page. By 1901, the New York directory was suggestive of a modern one. It contained 760 two-column pages. There were in it the names and numbers of more than 120,000 subscribers in New York City, Brooklyn, and New Jersey.

Growth of this sort was taking place all over the country. It is easy to see, therefore, how rapidly the publishing of directories ceased to be a matter of purely local interest and became a matter of general importance.

Legibility Is a Primary Requisite

While it was satisfactory to print the earliest directories on any suitable paper supplied by a local printer, it soon became apparent that not only the printing of the books but the paper itself would have to be given serious study. Machine finished book paper had at first been used rather generally; but as the number of telephones increased, with a corresponding increase in both the size of the individual books and in the number required, a thinner paper was needed to offset the sheer bulk of the metropolitan directories. Listings began to be printed on newspaper stock in weights ranging from 32 pounds to 28 pounds. This was an improvement in some respects, of course, but it could not be considered entirely satisfactory. There are important differences between newspapers and directories. Newspapers are read and thrown away. A directory may be referred to many times a day until a new directory comes out, an interval of six months or longer. Dirt specks, or glossy spots which do not take ink well ("shiners" is the trade name for them), do not interfere appreciably with the usefulness of a newspaper. Blurred type does not prevent arriving at the sense of a newspaper article even if a word or two is illegible.

EDWIN HOLMES, President. W. C. HUMSTONE, Gen'l Supt.

LIST OF SUBSCRIBERS

—TO THE—

Central Office System

OF THE

BELL TELEPHONE COMPANY OF NEW YORK.

BANKS, BANKERS AND BROKERS.

Arthur & Ketcham,	34 Wall St.
Britton & Barr,	27 Wall St.
Bloodgood, John & Co.	82 Broadway
Blake Bros. & Co.	34 Wall St.
Clarkson, Fred. W. & Co.	64 Pearl St.
Clark, Wm. M.	1 Broad St.
Dunning, E. J. Jr.	63 Wall St.
Forrester & Gemmell,	36 Broad St.
Friedmann & Co.	17 Broad St.
Frank, E. L. & Co.	52 Exchange Pl.
German Savings Bank,	4th Avenue & 14th St.
Glendenning, Davis & Co.	17 Wall St.
Gwynne & Day,	16 " "
Halch, W. F. & Sons,	34 " "
Hibners, McGowan & Co.	60 " "
Iselin, A. & Co.	48 Wall St.
Josep, Pakes & Co.	52 William St.
Johnson & Bell,	54 Wall St.
Kennedy, Hutchinson & Co.	40 " "
Kidder, A. M. & Co.	Cor Bway & Wall
Lawrence Bros. & Co.	18 Wall St.
Leffler, A. & Co.	38 Exchange Place
Leland, Chas. H.	21 Nassau St.
Livermore, Edward	59 " "
Manuel, Horrace & Co.	30 Wall St.
Musgrave & Co.	6 " "
Moore, W. D. & Co.	66 Exchange Place
Pearl & Co.	64 Broadway

TEA AND COFFEE.

Avis, Wm. A. & Co.	108 Pearl St.
Arnold, B. G. & Co.	125 Front St.
Carter, Hawley & Co.	104 Water St.
Edwards & Ranworth.	58 Wall St.
Faile, C. N.	130 & 132 Water St.
Mayer Brothers & Co.	79 Wall St.
Sisser H.	71 Vesey St.
" "	196 Bowery
" "	50 & 52 Watts St.

FISH AND MEATS.

Blackford Eugene F.	40 Fulton Market
Ottman Wm. & Co.	31 "

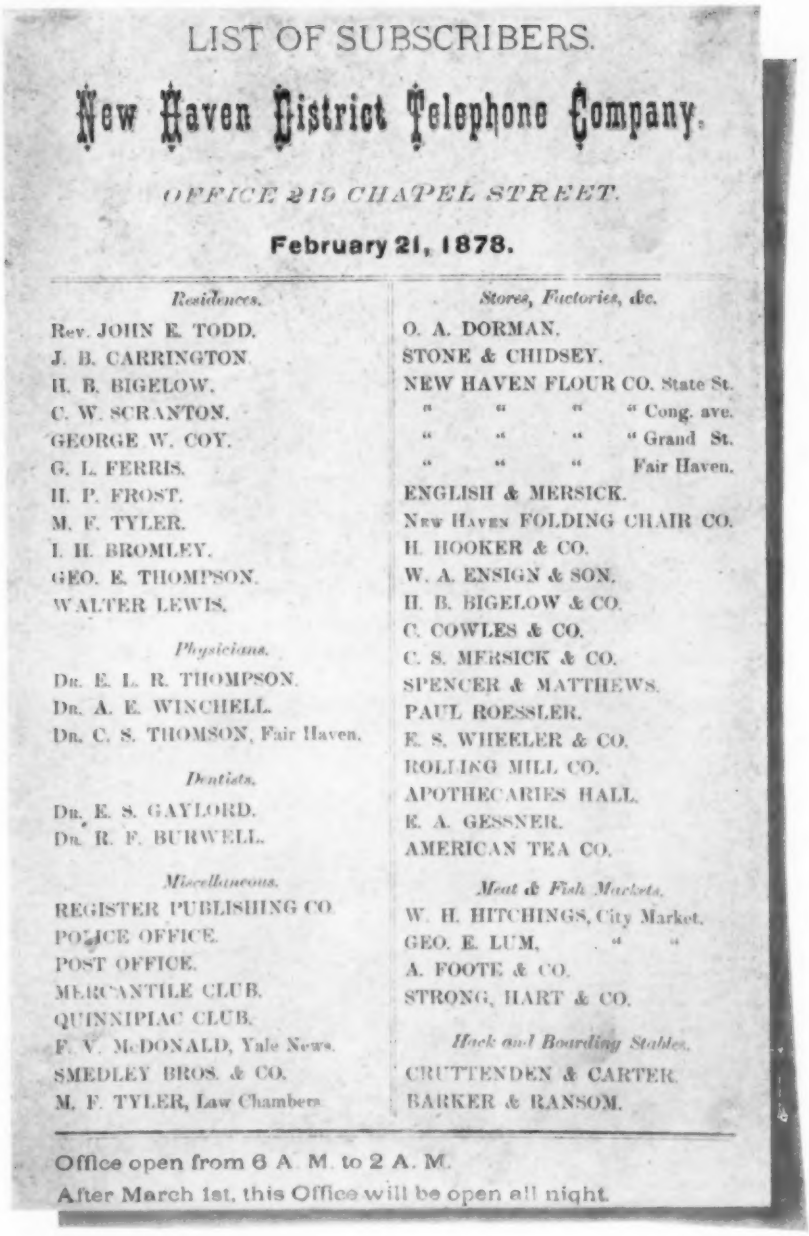
Produce, Cotton, Oil, and Commission Merchants.

Babcock & Cox,	67 Broad St.
Brown & Co.	108 "
Dows, David & Co.	20 South St.
Franch & Travers,	25 William St.
Oraininger Wilmot,	48 Broad St.
Green Bros.	132 Pearl St.
Hess L & Co.	17 South St.
Herold Emil,	25 William St.
Hollister & Chamberlin,	99 Broad St.
"	28d St. & 11th Ave.
Hoyt, Jesse & Co.	19 South St.
Javis & Co.	47 Broad St.

A SECTION OF NEW YORK CITY'S FIRST TELEPHONE DIRECTORY, ISSUED ON A SINGLE SHEET IN THE FALL OF 1878.

THE SEVEN DIRECTORIES WHICH LIST NEW YORK CITY'S TELEPHONES TODAY.

In the foreground is the 1100-page Manhattan Alphabetical. Behind it are (left to right): Manhattan Classified, Brooklyn Classified, Staten Island Combined, Bronx Combined, Brooklyn Alphabetical, and Queens Combined.



LIST OF SUBSCRIBERS.

New Haven District Telephone Company.

OFFICE 219 CHAPEL STREET.

February 21, 1878.

Residences.

Rev. JOHN E. TODD.
J. B. CARRINGTON.
H. B. BIGELOW.
C. W. SCRANTON.
GEORGE W. COY.
G. L. FERRIS.
H. P. FROST.
M. F. TYLER.
I. H. BROMLEY.
GEO. E. THOMPSON.
WALTER LEWIS.

Physicians.

DR. E. L. R. THOMPSON.
DR. A. E. WINCHELL.
DR. C. S. THOMSON, Fair Haven.

Dentists.

DR. E. S. GAYLORD.
DR. R. F. BURWELL.

Miscellaneous.

REGISTER PUBLISHING CO.
POLICE OFFICE.
POST OFFICE.
MERCANTILE CLUB.
QUINNIPIAC CLUB.
F. V. McDONALD, Yale News.
SMEDLEY BROS. & CO.
M. F. TYLER, Law Chambers.

Stores, Factories, &c.

O. A. DORMAN.
STONE & CHIDSEY.
NEW HAVEN FLOUR CO. State St.
" " " " Cong. ave.
" " " " Grand St.
" " " Fair Haven.
ENGLISH & MERSICK.
NEW HAVEN FOLDING CHAIR CO.
H. HOOKER & CO.
W. A. ENSIGN & SON.
H. B. BIGELOW & CO.
C. COWLES & CO.
C. S. MERSICK & CO.
SPENCER & MATTHEWS.
PAUL ROESSLER.
E. S. WHEELER & CO.
ROLLING MILL CO.
APOTHECARIES HALL.
E. A. GESSNER.
AMERICAN TEA CO.

Meat & Fish Markets.

W. H. HITCHINGS, City Market.
GEO. E. LUM, " "
A. FOOTE & CO.
STRONG, HART & CO.

Hack and Boarding Stables.

CRUTTENDEN & CARTER.
BARKER & RANSOM.

Office open from 6 A. M. to 2 A. M.
After March 1st, this Office will be open all night.

THE FIRST TELEPHONE DIRECTORY EVER PRINTED, ISSUED IN NEW HAVEN, CONN., ABOUT THREE WEEKS AFTER THE OPENING THERE OF THE WORLD'S FIRST COMMERCIAL TELEPHONE EXCHANGE.

But if a telephone number fails to be perfectly clear, difficulties arise at once.

By 1908, the original New York directory had been split into six separate books (New York City, New York-Suburban, Rockland County, New Jersey, Westchester, and Long Island) and the page size had been increased to 9½ inches × 11⅛ inches to accommodate first three, then four, columns of listings. In 1915 the directory problem was attacked on a broad and systematic basis. The total directories distributed at that time had reached a figure something more than twice the present circulation of America's most popular five-cent magazine. Obviously, directory publishing not only was developing into an important operation but such aspects of the work as printing techniques and the insurance of a supply of suitable paper called for specialized handling if improvement were to be shown.

Advantages of Group Purchasing Recognized

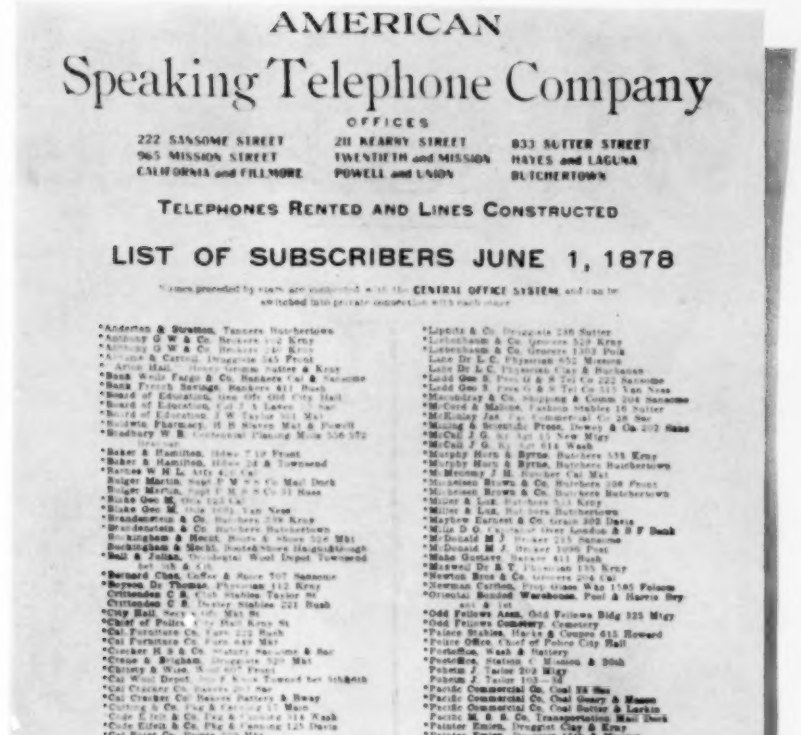
The American Telephone and Telegraph Company, recognizing that directory problems would tend to increase rather than diminish as time went on, suggested that Bell System Operating Companies would be benefited if directory publishing were considered collectively and if, as far as practicable, printing standardization were arrived at. The idea was most favorably received. Soon, a small group under a Directory Engineer was undertaking to study the System's directory problems as a whole. At about the same time, the purchasing department of the Western Electric Company arranged to handle the purchase of directory paper and printing. By the end of 1919, more than half the Operating Companies had turned over to the Western Electric Company the purchasing of the directory printing job, so that within that affiliate a group of specialists had been drawn together. As a matter of fact, in view of the increasing paper tonnage demand, it is questionable whether an economical supply could have been arranged for by

any means other than purchase centralization. By pooling paper requirements, hand-to-mouth buying could be avoided. The System demand could be met on a long-term basis by suitable mills in various parts of the country.

With the World War causing constant fluctuations in paper prices and with the demand for newsprint greater than it had ever been (in 1920 the price of newsprint reached an all time high of $130.00 a ton), printers found themselves beset with innumerable difficulties. They could not always secure deliveries on spot orders. They could not place long term paper contracts when they were operating under comparatively short term printing agreements. Perhaps most important of all considerations, the printers were unable to exert a satisfactory control over paper quality.

Standardizing the System's Paper Requirements

The time had come, therefore, for the Bell System's directory paper requirements to be viewed no longer from a sectional but from a national aspect. The special purchasing group in the Western Electric Company and the engineers of the American Company were already conversant with many phases of the paper industry, but studies became more detailed and more intensive. Not only did the specialists visit the principal paper mills of the country but they took stock of timber reserves, water power facilities, production capacities, and trade practices. As a result, they acquired a basic understanding of raw materials, labor, marketing, distribution, and all other factors which entered into the final price of finished paper. Through the 1919–20 boom and the following 1921 depression, Bell System paper requirements were met, satisfactorily and economically. Centralized purchasing of paper had made it possible to award contracts for relatively large tonnage. The mills could not have interrupted their regular production to produce small quantities periodically.



AMERICAN

Speaking Telephone Company

OFFICES

222 SANSOME STREET — 211 KEARNY STREET — 833 SUTTER STREET
965 MISSION STREET — TWENTIETH and MISSION — HAYES and LAGUNA
CALIFORNIA and FILLMORE — POWELL and UNION — BUTCHERTOWN

TELEPHONES RENTED AND LINES CONSTRUCTED

LIST OF SUBSCRIBERS JUNE 1, 1878

Names preceded by stars are connected with the CENTRAL OFFICE SYSTEM, and can be switched into private connection with each other.

*Anderton & Stratton, Tanners Butchertown
*Anthony G W & Co, Brokers 302 Kray
*Anthony G W & Co, Brokers 302 Kray
*Arrigoni & Carroll, Druggists 345 Front
* Arion Hall, Union between Sutter & Kray
*Bank Wells Fargo & Co, Bankers Cal & Sansome
*Bank French Savings, Bankers 411 Bush
*Board of Education, See Off Old City Hall
*Board of Education, Jul P A Lakey Cor
*Board of Education, J W Taylor 301 Mkt
*Baldwin Pharmacy, H H Haven Mkt & Powell
*Bradbury W B, Centennial Planing Mills 536 552 Brannan
*Baker & Hamilton, Hdwe 7 10 Front
*Baker & Hamilton, Hdwe 241 & Townsend
*Barnes W H L, Atty 4 5 Ex
Bulger Martin, Supt P M S S Co Mail Dock
Bulger Martin, Supt P M S S Co 31 Howe
*Blake Geo M, Dies 123 Ex
*Blake Geo M, Dies 1003 Van Ness
*Brandenstein & Co, Butchers 209 Kray
*Brandenstein & Co, Butchers Butchertown
Buckingham & Hecht, Boots & Shoes 526 Mkt
Buckingham & Hecht, Boots & Shoes Washington
*Bell & Julian, Residential Wood Depot Townsend bet 5th & 6th
*Bernard Chas, Coffee & Spice 707 Sansome
*Bergen Dr Thomas, Physician 112 Kray
Crittenden C A, Cash Stables Taylor St
Crittenden C E, Deputy Stables 221 Bush
*City Hall, Navy Cash Mkt St
*Chief of Police, City Hall Kray St
*Cal Furniture Co, Furn 222 Bush
*Cal Furniture Co, Furn 649 Mkt
*Crocker H S & Co, Stocks Sansome & Bat
*Cross & Brigham, Druggists 529 Mkt
*Christy & Wise, Wool 607 Front
*Cal Wool Depot, Jno F Knox Townsend bet 5th&6th
*Cal Cracker Co, Bakers 201 Bat
*Cal Cracker Co, Bakers Pattery & Bway
Cutting & Co, Fire & Burglar 15 Main
Cutter Estes & Co, Fire & Burglar 314 Wash
Cutter Estes & Co, Fire & Burglar 325 Davis
*Cal Paint Co, Paints 325 Mkt
*Cal Paint Co, Paints 27 Sansome
*Centennial Planing Mills, W H Bradbury 536 552 Brannan
*Caminetti J, The Financier Sutter & Kray
Chy Long & Co, Chinese Mchts 521 Kray
Chy Long & Co, Chinese Mchts 540 Sac
Cloh Brothers, Liquors Taylor St
*Cohn Sanderson & Cook, Brokers 312 Pine
*Cal Electrical Wks, Electricians 134 Sutter
*Day Thos, Gas Fitter 122 Sutter
Dentist Stables, Livery 221 Bush
*Deming Palmer & Co, Flour Mills 202 Davis
*Dewey & Co, Publishers 202 Sansome
*Dewey & Co, Publishers 414 Clay
*Dunphy & Hildreth, Butchers 525 Kray
*Dunphy & Hildreth, Butchers Butchertown
*Dry Dock Co, Dry Docks Hunters Point
*Eagles House, Fire Theft Prot & Webster
*Eureka Warehouse, A J Snow Mgr & Chestnut
*Eldridge Oliver, Free Dry Dock Co 516 Cal
* Fountain The, Saloon Sutter & Kray
*Fashion Stables, Livery Sutter St
*Field Stephen D, Electrician 2310 Cal
*Gallagher Thos J, Atty 402 Cond
*Gilbert & Moore, Paints 210 Bush
*Gladding McBean & Co, Drain&SewerPipe 213 Mkt
*Gladding McBean & Co, Drain&SewerPipe 1312 Mkt
*Ghirardelli & Ducrot, Coffee & Spice 415 Jackson
*Guittard E & Co, Coffee & Spice 405 Sansome
*Guittard E & Co, Coffee & Spice 209 Front
*Grangers' Business Assn, Produce 108 Davis
Grun & Vogelsang, Saloon 235—3d
Grun & Vogelsang, Saloon 142—4th
Grand Opera House, Theatre Mission St
*Gamble James, W U Tel Co 300 Pine
*Gove A J, Lumber Wharf Chestnut & Mtgy
*Hunt D D, Druggist 5th & Folsom
*Howes E K & Co, Woodenware 122 Front
*Howes E K & Co, Woodenware 37 Main
*Hochheimer B, Mdse Broker 205 Front
*Journal of Commerce, Publishers Clay & Sansome
*Kiel P C, Druggist 4th & Mkt
*Kong Jno F, Cal Wool Depot Townsend bet 5th & 6th
*Langley Chas & Co, Druggists Front & Pine
*Lipsitz & Co, Druggists 246 Sutter
*Lethenham & Co, Grocers 529 Kray
*Lethenham & Co, Grocers 1303 Polk
Lane Dr L C, Physician 852 Mission
Lane Dr L C, Physician Clay & Buchanan
*Ladd Geo S, Pres G & S Tel Co 222 Sansome
*Ladd Geo S, Pres G & S Tel Co 315 Van Ness
*Macondray & Co, Shipping & Comm 204 Sansome
*McCord A Malone, Fashion Stables 16 Sutter
*McKinley Jas, Jr, Commercial Co 28 Sac
*Manning & Scientific Press, Dewey & Co 202 Sans
*McCall J G, Sec Spr 113 New Mtgy
*McCall J G, Sec Spr 614 Wash
*Murphy Horn & Byrne, Butchers 533 Kray
*Murphy Horn & Byrne, Butchers Butchertown
*McMenomy J M, Butcher Cal Mkt
*Monsalvatt Brown & Co, Butchers 106 Front
*Monsalvatt Brown & Co, Butchers Butchertown
*Miller & Lux, Butchers 533 Kray
*Miller & Lux, Butchers Butchertown
*Mayhew Earnest & Co, Grain 302 Davis
*Mills D O, Cashier Over Land Co & B F Bank
*McDonald M J, Broker 215 Sansome
*McDonald M J, Broker 1006 Post
*Mahe Gustave, Banker 411 Bush
*Maxwell Dr E T, Physician 135 Kray
*Newton Bros & Co, Grocers 204 Cal
*Newman Carlton, Prop Grand Way 1501 Folsom
*Oriental Bonded Warehouse, Pool & Harris Dry Goods & 101
*Odd Fellows Assn, Odd Fellows Bldg 325 Mtgy
*Odd Fellows Cemetery, Cemetery
*Palace Stables, Harris & Cowper 615 Howard
*Police Office, Chief of Police City Hall
*Portoffice, Wash & Battery
*Postoffice, Station C, Mission & 20th
Pohstal J Taylor 202 Mtgy
Pohstal J Taylor 103—12
*Pacific Commercial Co, Coal 18 Sac
*Pacific Commercial Co, Coal Quary & Mason
*Pacific Commercial Co, Coal Sutter & Larkin
Pacific M S S Co, Transportation Mail Dock
*Painter Emlen, Druggist Clay & Kray
*Painter Emlen, Druggist 11th & Mission
*Poly Heilbron & Co, Butchers 330 Kray
*Poly Heilbron & Co, Butchers Butchertown
*Pool & Harris, Oriental Whse Bryant & 1st
Quong Lee, Chinese Mcht 620 Dupont
Quong Lee, Chinese Mcht 608 Mkt
Quong Lee, Chinese Mcht 410 Kray
Redington & Co, Druggists 529 Mkt
*Richards C P & Co, Druggists Clay & Sansome
*S F & Pac Glass Wks, C Newman King &
Sloss L F, Warehouse Battery & Union
*Sherman H B, Druggist Mkt & Powell
*Selig M, Butcher 531 Kray
*Selig M, Butcher Butchertown
*Stallard Dr J H, Physician 37 Post
*Salon Jno L, Supt G & S Tel Co 1412 Pierce
*Stern Victor H, 6 Chasmore&Co 230 & 2 Jno At
*Taylor John & Co, Druggists Glassware 512 Wash
Taylor Jno W, Gutta Percha 501 Mkt
*Davis Lloyd, Capitalist Bank of W F & Co
Trumpour J F, Dentist 2021 Mission
Trumpour J P, Dentist 401½ Hayes
*Tay Geo H & Co, Stoves & Tinware 614 Battery
*Underwriters' Fire Patrol, Erker & Stevenson
*United Carriage Co, Hacks & Coupes Palace Hotel
*United Carriage Co, Hacks & Coupes Sutter&Larch
United Workingmen, Boot&Shoe Co 416 Mkt
United Workingmen, Boot&Shoe Co 251h&Bartlett
*Verdenal D F, Mining Secy 327 Pine
*Verdenal D F, Mining Secy 1525 Sutter
Vermel & Wellington, Hay & Grain 606—4th
Vermel & Wellington, Hay & Grain 4th & Berry
*Western Union Tel Co, Pine & Mtgy
White Capt Russell, Fire Patrol Stevenson St
White Capt Russell, 607½ Howard
West Coast Furniture Co, Furniture 4th & Bryant
*Wilcox J C, Oakland Express & Sac
*Williams Blanchard & Co, Agts P M SS Co 210 Cal
*Wellman Peck & Co, Grocers 416 Front
*Whitney & Webster, Wool Wharf King St
*Waldstein A, Lithographer Sac & Sansome
*Waldstein A, Lithographer King nr 2d
*Wangenheim Sol, Pkg & Canning 127 Davis
*Wells Fargo & Co's Bank, Bankers Cal & Sansome
*Willard C H, Broker Safe Deposit Bldg
Wilson J Y & Co, Prov Packers 306 Mkt

THE FIRST TELEPHONE DIRECTORY TO LIST SUBSCRIBERS ALPHABETICALLY WAS ISSUED IN SAN FRANCISCO.

Telephones Rented and Lines Constructed

LIST OF SUBSCRIBERS

September 15th, 1878.

Names preceded by star (*) are connected with the Central Office System, and can be switched into private connection with each other.

Amer'n Dist. Car'ge & Exp. Co.	Coupes and Exp. Wagons	15 Congress Street West.
Amer'n Dist. Car'ge & Exp. Co.	Coupes and Exp. Wagons	110 Larned Street West.
*American Express Co.		Griswold and Larned Sts.
*Baker, F. G.	Customs Broker	Custom House.
Baugh Steam Forge Co.	Steam Forge	2 Moffat Block.
Baugh Steam Forge Co.	Steam Forge	Springwells.
*Burton, J. C.	Insurance Agent	53 Griswold Street.
*Buhl, Newland & Co.	Wholesale Hatters	146 and 148 Jefferson Ave.
*Buhl, Ducharme & Co.	Wholesale Hardware	103 to 111 Woodbridge West.
*Berry Bros.	Varnish and Japan Mfgs.	Lieb and Wight Streets.
*Balch & Norton.	Grain Commission	Woodbridge and Shelby Sts.
*Beeson, Jacob & Co.	Grain Commission	58 Woodbridge St. West.
*Brunswick Hotel	Hotel	Griswold and State Sts.
*Bissell, E. W.	Forwd. and Commission	Foot First Street.
*Canada Southern Railroad	Ticket Office	153 Jefferson Avenue.
*Canada Southern Railroad.	Freight Office	Woodbridge and 7th Sts.
*Case, Geo. F.	Livery Stable	38 Larned Street West.
*Coates, J. G.	Manager Mutual Ben. Asso.	Wayne Co. Savings Bank.
*Collier, W. W.	Wholesale Iron Dealer	Atwater, Foot of Shelby.
*Cornwells, Price & Co.	Wholesale Paper	116 Jefferson Avenue.
*Calvert Lithograph Company.	Lithographers	Tribune Building.
*Davenport, F. O.	Insurance Agent	32 & 34 Congress St. West.
*Davenport, F. O.	Residence	162 Congress Street East.
*Detroit & Milwaukee Railroad.	Freight Office	Foot Brush Street.
*Detroit & Milwaukee Railroad,	Elevator	Foot Hastings Street.
*Detroit & Milwaukee Railroad.	Ferry Slip Dock	Foot Antoine Street.
*Detroit & Milwaukee Railroad.	Purchasing Agent	Atwater and Orleans Sts.

THIS DETROIT, MICHIGAN, DIRECTORY WAS THE FIRST TO INCLUDE BUSINESS OCCUPATIONS WITH AN ALPHABETICAL LISTING.

In the meantime, the New York City alphabetical directory once more suffered growing pains. The book had attained such proportions that some means of reducing bulk had to be discovered. The answer was to decrease the thickness of the paper. At the time, most directories were being printed on 28 pound stock. It was proposed that metropolitan directories be printed on 22½ pound paper. Experience had revealed that there were only a few "catalog" mills technically equipped to make this lightweight paper. After experimentation with some of these mills had produced a satisfactory 22½ pound paper, contracts were awarded and the requirements divided between eastern and western mills. This arrangement avoided the possibility of overload on any one mill, lowered cost of delivery from mill to printer, and offered a solution to possible tonnage emergencies.

Controlling Sources of Waste

By 1923, the value of centralized purchasing, whereby large tonnage long term contracts might be let, had been demonstrated. The next step for the future was the gradual and continuous improvement of paper quality.

Already, due to the nature of contracts and to technical work with the mills, savings to the System aggregating thousands of dollars had been effected through waste reduction. In the manufacture and transportation of directory paper rolls there had been two principal sources of what the buyer considered waste. These arose from trade practices connected with (1) weight allowances and (2) methods of wrapping the roll for shipment.

In the matter of weight, a tolerance of five per cent over or under the specified weight was allowed by trade custom. As roll paper is paid for on the basis of actual rather than ordered weight, delivery of paper in excess of the contract basis weight would naturally increase the cost of the paper (and, inci-

dentally, the shipping cost) correspondingly. With the co-operation of the mills which supplied the Bell System, better control of manufacturing processes was established and a 50 per cent reduction in weight tolerance resulted.

Roll wrappers, used to protect the directory paper while in transit, averaged two per cent of the total weight of the roll. The paper user paid for the full wrapped weight of the roll at the contract rate per pound of the directory stock. In other words, two per cent of what he paid for was useless for printing. Again, working closely with the mills, improvements in wrapper quality and methods were brought about with a subsequent lowering of wrapper weight by more than 25 per cent.

Establishing Specifications for Directory Paper

Betterments of this nature were, of course, desirable. It was felt, however, that—with sources of paper supply now satisfactorily established through centralized purchase contracts—a skeptical eye should be turned upon all phases of directory publishing, from paper to presswork, to see if there could not be revealed ways of improving the publication as a reference medium. In 1923, a series of regional directory conferences of representatives of the American Telephone and Telegraph Company and the Operating Telephone Companies produced many definite suggestions with respect to ink, plates, typography and kindred subjects. Upon the directory staff of the Headquarters Company there naturally fell the task of co-ordinating these suggestions and of developing, through specialized study, definite recommendations for improvement. Several discussions of printing improvements reflecting these activities have previously been published in the Bell Telephone Quarterly.

These 1923 conferences also placed directory paper as an item for regular consideration by the paper testing laboratories of the American Company. Other Bell System standard

papers, such as bonds, ledgers, and writings, had been studied by these technicians for several years. With laboratory supervision of quality, and another series of mill inspections, engaged in by Western Electric purchasing specialists and the technicians of the paper testing laboratories, a continuous effort to improve directory paper stock was launched. It was realized that betterments might be hoped for in general appearance: that is, in color and cleanliness, finish and surface texture; and in such physical characteristics as bulk, weight, legibility of the printed page, opacity (ability to print on both sides without showing through) and strength to withstand high speed printing and, in finished book form, frequent handling.

An innovation was the drawing up of paper specifications. At that time, the newsprint industry was not accustomed to manufacture a paper to meet specifications established by customers. There was no need for them so far as the general run of newsprint consumers was concerned. Directory paper was another matter.

With a standard directory paper established through specifications, definite progress in quality refinements was possible. A series of practical experiments showed that it was feasible to bring about improvement in color by greater technical refinements in manufacturing.

This search for quality in directory paper, without departure from reasonableness in the matter of costs, may be said to have been well launched by 1923 and to have been continuously pressed ever since.

Technical progress, contributed to by paper manufacturer, printer, and System specialists alike, has accounted for the improvement. Gradually, paper stock used for directory printing has changed from ordinary newsprint through a superior grade of newsprint to a clean, "blue-white," durable catalog paper.

The basic answer to the "why" is, of course, the Bell System's traditional search for improved methods. The "how"

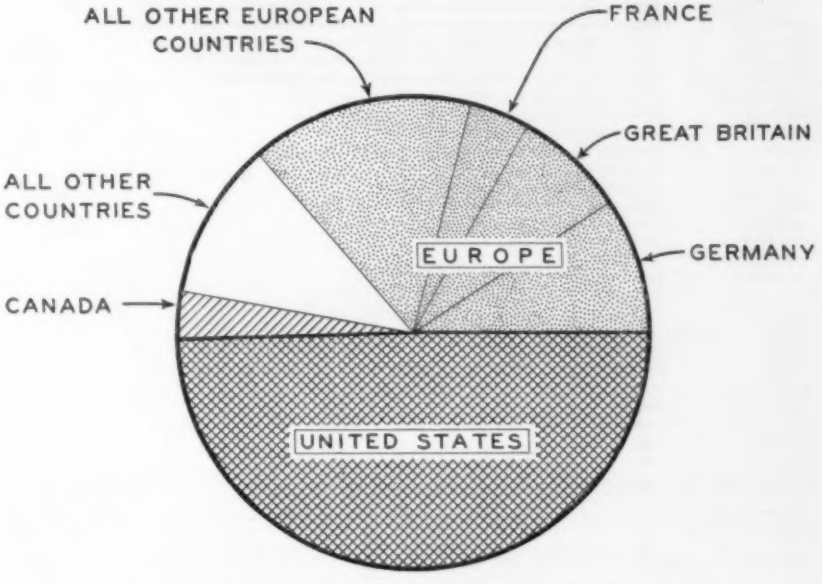
is supplied by the concentration of trained minds upon the problem. Directory paper is a good example of the way in which the System refuses to be content with present standards if desirable improvements are to be gained by bettering them.

M. P. WOODARD

World's Telephone Statistics

JANUARY 1, 1938

THE year 1937 was marked by increased activity in the telephone field throughout the world. The net addition of 2,146,985 telephones to the wire networks of the world was the largest annual increase ever recorded. This gain brought the total number of telephones in the world on January 1, 1938,



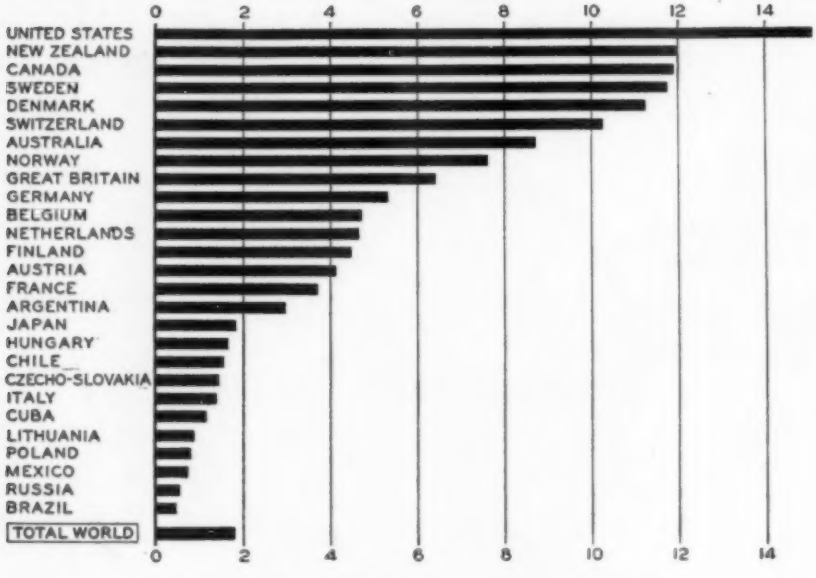
DISTRIBUTION OF THE WORLD'S TELEPHONES, JANUARY 1, 1938

to 39,245,069, as shown by the latest annual survey of the world's telephone statistics undertaken by the Chief Statistician's Division of the American Telephone and Telegraph Company. This survey was based upon information supplied by private and governmental communication organizations in

every country, and its results have been issued in a pamphlet entitled "Telephone and Telegraph Statistics of the World, January 1, 1938." In the following pages there are reproduced a number of the tables and charts contained in this pamphlet, all figures referring to the beginning of 1938 or, in the case of message data, to the year 1937.

World Totals

Approximately one-half of the total number of telephones in the world at the beginning of 1938 were in the United States,



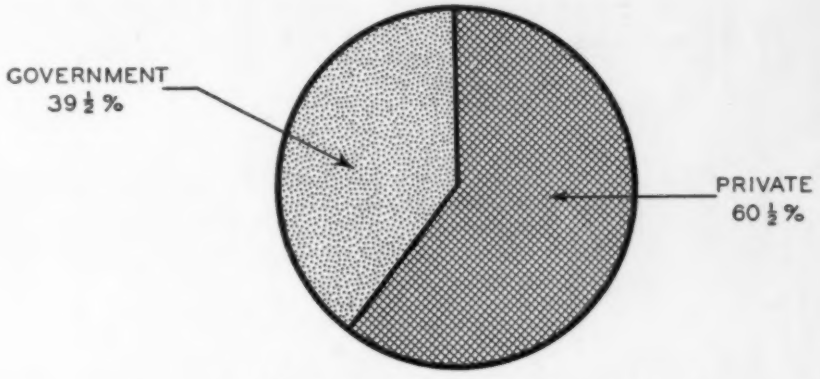
Telephones per 100 Population, January 1, 1938

as will be seen from the following summary:

	Telephones		Telephone Wire	
	Number	Per 100 Pop.	Miles	Per 100 Pop.
United States	19,453,401	15.09	90,831,000	70.47
Rest of World	19,791,668	0.96	77,742,000	3.77
Total World	39,245,069	1.79	168,573,000	7.67

In relation to population, the number of telephones in the United States was nearly sixteen times that in the rest of the world.

About 60 per cent of the world's telephones were owned and operated by private companies, including 4,309,464 privately operated telephones outside the United States. The remaining 40 per cent were owned and operated by governmental agencies, the larger portion (12,415,244) being in Europe. Twenty million, or 51 per cent of the world total, were dial telephones connected to machine switching offices; approximately 8,500,000 of these dial telephones were in service in the United States.



OWNERSHIP OF THE WORLD'S TELEPHONES, JANUARY 1, 1938

The world's telephone wire mileage, aggregating over 168,000,000 miles, is equivalent to a two-wire circuit over 350 times the mean distance between the earth and the moon in length. It corresponds to more than 400 feet of wire for every person in the world, or to 4.3 miles per telephone in service.

COMPARATIVE DEVELOPMENT BY COUNTRIES

The conventional method of comparing the relative extent of telephone facilities states the number of telephones as a per-

TELEPHONE DEVELOPMENT OF THE WORLD, BY COUNTRIES
January 1, 1938

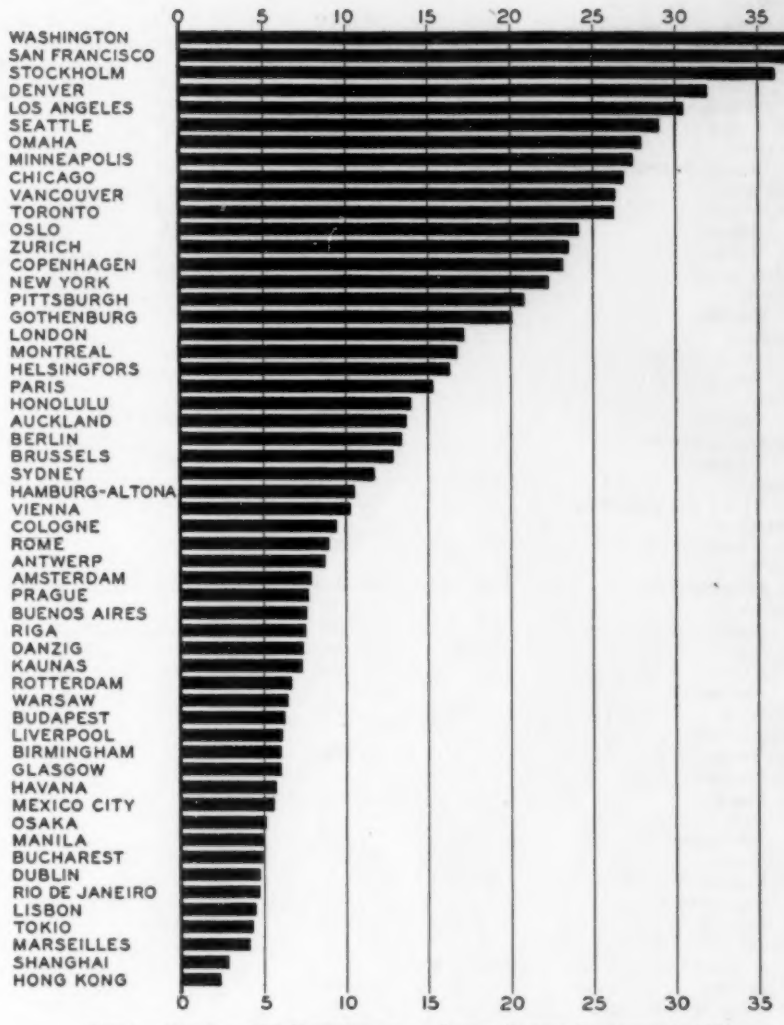
Countries	Number of Telephones: Government Systems	Private Companies	Total	Per Cent of Total World	Telephones Per 100 Population
NORTH AMERICA:					
United States	—	19,453,401	19,453,401**	49.57%	15.09
Canada	199,150	1,123,644	1,322,794	3.37%	11.90
Central America	12,520	16,033	28,553	.07%	0.40
Mexico	1,337	136,744	138,081	.35%	0.72
West Indies—					
Cuba	610	50,553	51,163	.13%	1.15
Puerto Rico	531	14,640	15,171	.04%	0.85
Other W. I. Places	9,015	16,943	25,958	.07%	0.36
Other No. Am. Places	—	14,900	14,900	.04%	4.13
Total	223,163	20,826,858	21,050,021	53.64%	11.68
EUROPE:					
Austria	281,790	—	281,790	.72%	4.12
Belgium#	393,528	—	393,528	1.00%	4.70
Bulgaria	25,532	—	25,532	.07%	0.40
Czecho-Slovakia	220,510	—	220,510	.56%	1.43
Denmark	17,950†	408,001	425,951	1.09%	11.25
Finland	6,743	164,998	171,741	.44%	4.48
France	1,552,618	—	1,552,618	3.96%	3.70
Germany†	3,623,697	—	3,623,697	9.23%	5.31
Great Britain and No. Ireland	3,029,456	—	3,029,456	7.72%	6.41
Greece	6,780	36,774	43,554	.11%	0.62
Hungary	148,595	744	149,339	.38%	1.65
Ireland (Eire)†	40,403	—	40,403	.10%	1.36
Italy	—	600,501	600,501	1.53%	1.38
Jugo-Slavia	59,022	—	59,022	.15%	0.38
Latvia†	77,230	—	77,230	.20%	3.90
Lithuania	22,042	—	22,042	.06%	0.87
Netherlands	401,484	—	401,484	1.02%	4.65
Norway*	135,007	87,003	222,010	.57%	7.61
Poland	146,562	125,738	272,300	.69%	0.79
Portugal	17,115	47,426	64,541	.16%	0.87
Roumania	—	81,205	81,205	.21%	0.41
Russia¶	950,000	—	950,000	2.42%	0.53
Spain	—	300,000	300,000	.76%	1.20
Sweden	737,102	1,596	738,698	1.88%	11.75
Switzerland	430,877	—	430,877	1.10%	10.26
Other Places in Europe	91,201	—	91,201	.23%	1.76
Total	12,415,244	1,853,986	14,269,230	36.36%	2.47

SOUTH AMERICA:					
Argentina	—	377,473	377,473	.96 %	2.96
Bolivia	—	2,555	2,555	.007%	0.08
Brazil	958	240,603	241,561	.62 %	0.47
Chile	—	70,867	70,867	.18 %	1.54
Colombia	8,500	30,259	38,759	.10 %	0.39
Ecuador	4,267	2,816	7,083	.02 %	0.28
Paraguay	—	3,133	3,133	.01 %	0.33
Peru	—	25,981	25,981	.07 %	0.39
Uruguay	32,823	11,245	44,068	.11 %	2.11
Venezuela	805	20,253	21,058	.05 %	0.61
Other So. Am. Places	2,869	—	2,869	.007%	0.52
Total	50,222	785,185	835,407	2.13 %	0.86
ASIA:					
British India†	31,075	49,156	80,231	.20 %	0.02
China	80,000	90,000	170,000	.43 %	0.04
Japan†	1,304,693	—	1,304,693	3.33 %	1.82
Other Places in Asia	172,583	93,684	266,267	.68 %	0.14
Total	1,588,351	232,840	1,821,191	4.64 %	0.17
AFRICA:					
Egypt	60,546	—	60,546	.16 %	0.27
Union of South Africa†	189,601	—	189,601	.48 %	1.90
Other Places in Africa	121,014	2,094	123,108	.31 %	0.10
Total	371,161	2,094	373,255	.95 %	0.24
OCEANIA:					
Australia*	594,855	—	594,855	1.51 %	8.71
Hawaii	—	30,794	30,794	.08 %	7.62
Netherlands East Indies	41,581	4,128	45,709	.12 %	0.07
New Zealand†	192,020	—	192,020	.49 %	11.97
Philippine Islands	1,256	26,651	27,907	.07 %	0.19
Other Places in Oceania	4,351	329	4,680	.01 %	0.19
Total	834,063	61,902	895,965	2.28 %	0.93
TOTAL WORLD	15,482,204	23,762,865	39,245,069§	100.00 %	1.79

* June 30, 1937.
** As reported by the United States Department of Commerce, Bureau of the Census.
# February 28, 1938.
† March 31, 1938.
¶ U.S.S.R., including Siberia and Associated Republics. (Estimated)
§ Includes approximately 20,000,000 automatic or "Dial" telephones, of which about 42% are in the United States.

centage of the total population served in each country or community. The table entitled "Telephone Development of the World, by Countries" shows, in the last column, the number of telephones per 100 population in each of the major countries of the world; and a graphical presentation of relative telephone development is shown in the chart "Telephones per 100 Population." The United States, with only 6 per cent of the world's population, had a development on January 1, 1938, of 15.09 telephones per 100 population, compared with an average telephone development in Europe of 2.47 and in the world as a whole of 1.79. It is of interest to note in this connection that some 87 per cent of Europe's telephones are owned and operated by governmental authorities.

The largest telephone system in absolute number of telephones in service, outside the United States, is that of Germany, where 3,623,697 telephones were in service on March 31, 1938. This, however, corresponds to only 5.31 telephones for every 100 people. The best developed countries telephonically, next to the United States, were New Zealand with 11.97 and Canada with 11.90 telephones per 100 population. Great Britain and Northern Ireland had 3,029,456 telephones, equivalent to 6.41 telephones per 100 population; France had 1,552,618 telephones, or 3.70 per 100 population; and Japan had 1,304,693 telephones, or 1.82 per 100 population. France, Germany, Great Britain and Japan are the only countries in the world, outside of the United States and Canada, with more than one million telephones, and they account in the aggregate for 24.24 per cent of the world's telephones. The average telephone development of these four countries, however, is only 4.15 per 1000 population, or 27.5 per cent of the United States' development. The highest telephone developments in Europe are found in Sweden (11.75 telephones per 100 population), Denmark (11.25) and Switzerland (10.26). These three countries, together with United States, Canada and New Zea-



TELEPHONES PER 100 POPULATION OF LARGE CITIES, JANUARY 1, 1938

TELEPHONE DEVELOPMENT OF LARGE CITIES
January 1, 1938

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones Per 100 Population
ARGENTINA:			
Buenos Aires	3,075,000	233,051	7.58
AUSTRALIA:			
Adelaide	318,000	34,177	10.75
Brisbane	318,000	33,417	10.51
Melbourne	1,024,000	127,516	12.45
Sydney	1,279,000	150,005	11.73
AUSTRIA:			
Graz	153,000	11,748	7.68
Vienna	1,878,000	192,149	10.23
BELGIUM:#			
Antwerp	560,000	48,696	8.70
Brussels	991,000	127,639	12.88
Liege	433,000	29,885	6.90
BRAZIL:			
Rio de Janeiro	1,860,000	87,609	4.71
CANADA:			
Montreal	1,063,700	178,518	16.78
Ottawa	193,300	38,590	19.96
Toronto	793,800	208,524	26.27
Vancouver	277,700	73,219	26.37
CHILE:			
Santiago	843,000	35,640	4.23
CHINA:			
Hong Kong	800,000	18,764	2.35
Shanghai††	1,600,000	45,495	2.84
CUBA:			
Havana	710,000	40,662	5.73
CZECHO-SLOVAKIA:			
Prague	965,000	74,586	7.73
DANZIG:			
Free City of Danzig	253,000	18,666	7.38
DENMARK:			
Copenhagen	873,000	201,987	23.14
FINLAND:			
Helsingfors	290,000	46,556	16.34
FRANCE:			
Bordeaux	260,000	22,739	8.75
Lille	200,000	18,155	9.08
Lyons	650,000	38,764	5.96
Marseilles	915,000	37,801	4.13
Paris	2,850,000	435,832	15.29
GERMANY:†			
Berlin	4,307,000	574,367	13.34
Breslau	624,000	47,011	7.53
Cologne	768,000	72,319	9.42
Dresden	821,000	72,144	8.79
Dortmund	577,000	27,385	4.75
Essen	672,000	34,931	5.20
Frankfort-on-Main	650,000	67,114	10.33
Hamburg-Altona	1,714,000	180,411	10.53
Leipzig	762,000	71,523	9.39
Munich	848,000	92,878	10.95
GREAT BRITAIN AND NO. IRELAND:†			
Belfast	415,000	22,308	5.38
Birmingham	1,260,000	75,960	6.03
Bristol	446,000	29,249	6.56
Edinburgh	460,000	42,923	9.33
Glasgow	1,140,000	68,784	6.03
Hull	358,000	23,488	6.56
Leeds	562,000	34,648	6.17
Liverpool	1,260,000	76,424	6.07
London—			
(City and County of London)	4,057,000	696,808	17.18
Manchester	1,005,000	66,560	6.62
Newcastle	477,000	26,526	5.56
Sheffield	517,000	26,924	5.21
HAWAII:			
Honolulu	150,000	20,914	13.94
HUNGARY:			
Budapest	1,606,000	100,677	6.27
Szeged	140,000	2,441	1.74
IRELAND (Eire):†			
Dublin	477,000	22,760	4.77

TELEPHONE DEVELOPMENT OF LARGE CITIES (Concluded)
January 1, 1938

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones Per 100 Population
ITALY:			
Milan	1,178,000	101,528	8.62
Naples	907,000	29,911	3.30
Rome	1,247,000	111,784	8.96
JAPAN:†			
Kobe	975,000	44,728	4.59
Kyoto	1,150,000	50,162	4.36
Nagoya	1,220,000	43,674	3.58
Osaka	3,260,000	165,486	5.08
Tokio	6,320,000	269,565	4.27
LATVIA:†			
Riga	390,000	29,310	7.52
LITHUANIA:			
Kaunas	108,000	7,906	7.32
MEXICO:			
Mexico City	1,423,000	79,384	5.58
NETHERLANDS:			
Amsterdam	790,000	62,348	7.89
Haarlem	170,000	14,080	8.28
Rotterdam	625,000	41,884	6.70
The Hague	535,000	53,926	10.08
NEW ZEALAND:†			
Auckland	209,000	28,530	13.65
NORWAY:*			
Oslo	250,000	60,331	24.13
PHILIPPINE ISLANDS:			
Manila	450,000	22,353	4.97
POLAND:			
Lodz	665,000	17,292	2.60
Warsaw	1,261,000	81,900	6.49
PORTUGAL:			
Lisbon	683,000	30,476	4.46
ROUMANIA:			
Bucharest	800,000	39,287	4.91
SWEDEN:			
Gothenburg	270,000	54,097	20.04
Malmö	148,000	25,920	17.51
Stockholm	458,000	165,248	36.08
SWITZERLAND:			
Basel	154,000	36,773	23.88
Berne	116,000	28,889	24.90
Geneva	150,000	29,938	19.96
Zurich	282,000	66,368	23.53
UNITED STATES: (See Note)			
New York	7,284,000	1,623,117	22.28
Chicago	3,520,000	945,598	26.86
Los Angeles	1,390,000	423,766	30.49
Pittsburgh	1,040,000	216,745	20.84
Total 10 cities over 1,000,000 Population	22,530,800	5,066,121	22.48
Milwaukee	790,000	155,500	19.68
San Francisco	721,000	275,204	38.17
Washington	584,700	226,957	38.82
Minneapolis	515,000	141,156	27.41
Total 10 cities with 500,000 to 1,000,000 Population	6,703,900	1,532,146	22.85
Seattle	423,200	122,884	29.04
Denver	317,000	101,277	31.95
Hartford	243,300	62,845	25.83
Omaha	236,100	65,974	27.94
Total 34 cities with 200,000 to 500,000 Population	10,580,200	2,150,960	20.33
Total 54 cities with more than 200,000 Population	39,814,900	8,749,227	21.97

NOTE: There are shown, for purposes of comparison with cities in other countries, the total development of all cities in the United States in certain population groups, and the development of certain representative cities within each of such groups.

* June 30, 1937.
‡ February 28, 1938.
† March 31, 1938.
†† International Settlement and French Concession.

land, are the only countries in the world with more than one telephone for each ten of the population.

Telephones in Large Cities

On January 1, 1938, New York City had 1,623,117 telephones, more than any other city in the world and, in fact, nearly as many as Berlin, London and Paris combined. Chicago had 945,598 telephones, or more than all of South America. The largest ten cities in the United States had more telephones than any single foreign country, and more than France and Great Britain combined.

Washington, D. C., leads all cities of the world in respect to relative telephone development, with 38.82 telephones per 100 inhabitants. Next in rank comes San Francisco, with 38.17 telephones per 100 inhabitants; San Francisco's 275,204 telephones exceed the combined telephone facilities of China and British India, which together contain over two-fifths of the entire population of the world. Highest in telephone development among foreign cities is Stockholm, with 165,248 telephones, corresponding to 36.08 per 100 inhabitants. Except for Stockholm, however, the telephone development of the world's best known foreign cities is far below American standards. London, for example, with 696,808 telephones on March 31, 1938, had 17.18 telephones per 100 inhabitants. On the same date there were 574,367 telephones in Berlin, or 13.34 for every 100 people. The 435,832 telephones in Paris on January 1, 1938 corresponded to 15.29 per 100 inhabitants. Despite this relatively lower telephone development of important European capitals, each large city actually contained a substantial proportion of the total number of telephones in its respective country. Thus, nearly one-fourth of all Great Britain's telephones were in London, one-sixth of Germany's telephones were in Berlin, while one-third of all the French telephones were in Paris. In the United States, no city has as

much as a tenth of the total number of telephones in the country.

Telephones in Smaller Communities

With respect to the telephone development of the smaller communities and more sparsely settled areas, in the three large countries of Europe—Germany, Great Britain and France—there were less than five telephones for every 100 people dwelling in communities with less than 50,000 population. In the Scandinavian countries, there were from 5 to 8.75 telephones for every 100 people in these smaller communities. In the United States, on the other hand, there were 10.84 telephones per 100 population in places with less than 50,000 inhabitants. This is higher than the comparable development of such localities in any other country in the world; it even exceeds the telephone development of important capital cities such as Budapest, Prague, Rome, The Hague, Tokio, Vienna and Warsaw. The total number of telephones serving these smaller American communities exceeds the aggregate number of telephones in France, Germany and Great Britain.

Telephone Traffic

During 1937, over 28 billion local and long distance telephone calls were completed in the United States. This is equal to some 900 messsages for each second of each day and night throughout the year, or to more than 220 messages for every man, woman and child in the United States. The average per capita calling rate for the world outside the United States during 1937 amounted to only 15.4.

* * * * * *

In conclusion, this survey shows that telephone facilities in America are far more extensive than those found in other countries. In addition, by means of cables, wires and over-

TELEPHONE DEVELOPMENT OF LARGE AND SMALL COMMUNITIES
January 1, 1938

Country	Service Operated by (See Note)	Number of Telephones		Telephones Per 100 Population	
		In Communities of 50,000 Population and Over	In Communities of less than 50,000 Population	In Communities of 50,000 Population and Over	In Communities of less than 50,000 Population
Australia**	G.	365,800	229,055	11.04	6.51
Austria	G.	218,611	63,179	9.91	1.36
Belgium#	G.	278,411	115,117	7.70	2.42
Canada	P. G.	732,289	590,505	19.83	7.95
Czecho-Slovakia*	G.	106,263	101,024	5.99	0.75
Denmark	P.	227,578	198,373	20.65	7.39
Finland	P.	64,592	107,149	12.89	3.21
France	G.	855,883	696,735	8.07	2.22
Germany†	G.	2,366,196	1,257,501	8.17	3.21
Great Britain and No. Ireland†	G.	2,200,000	885,000	8.04	4.45
Hungary	G.	113,633	35,706	4.91	0.53
Japan†	G.	903,367	401,326	3.80	0.84
Netherlands	G.	257,852	143,632	7.16	2.85
New Zealand†	G.	80,957	111,063	14.23	10.73
Norway**	P. G.	89,465	132,545	21.98	5.28
Poland	P. G.	172,401	99,899	3.71	0.33
Sweden	G.	285,573	453,125	25.87	8.75
Switzerland	G.	197,721	233,156	21.87	7.07
Union of South Africa†	G.	117,777	71,824	8.29	0.84
United States	P.	11,196,576	8,256,825	21.23	10.84

Note: P. indicates that the telephone service is wholly or predominantly operated by private companies, G. wholly or predominantly by the Government, and P. G. by both private companies and the Government. See first table.

* January 1, 1937.
** June 30, 1937.
# February 28, 1938.
† March 31, 1938.

seas radio circuits, the American telephone user can reach 93 per cent of the world's telephones, the total of which, it is estimated, will pass the 41,000,000 mark in 1939. These telephone statistics are evidence of the greater usefulness and value of telephone service in America than elsewhere.

K. FICK

Notes on Recent Occurrences

STATEMENT READ BY WALTER S. GIFFORD, PRESIDENT AMERICAN TELEPHONE AND TELEGRAPH COMPANY, AT ANNUAL MEETING OF STOCKHOLDERS, APRIL 19, 1939

OUR Annual Report for 1938 which was sent to all stockholders on the first of March set forth fully the operations for the year. It would hardly seem appropriate to take the time of this meeting to again detail them. Also, only four days ago you received the usual quarterly dividend of $2.25 a share together with the latest earnings figures and a short statement as to the increase in the number of telephones and in the number of toll and long distance conversations for the first quarter of 1939. You will have noted that the System as a whole earned $2.26 for the three months ending February 28, 1939, as compared with $1.94 for the corresponding three months a year ago. Currently we are now earning the dividend. As you know, in 1938, earnings were $12,638,000 short of the $9 per share dividend which was paid. As stated in the Annual Report, taxes continue to rise and it now looks as if taxes in 1939 would be some $9,000,000 more than in 1938. If taxes were today relatively the same as in 1935, and with revenues and other expenses what they are, the current earnings would be between $2 and $3 a share greater than they are.

The System now has approximately 16,000,000 telephones in service—an all time high. This is some 800,000 telephones more than the pre-depression peak in 1930 which was not reached again until October, 1937. The gain in telephones over 1930 varied in different sections of the country. Practically all sections, however, show some gain, except the north-

eastern section which still has slightly less telephones than in 1930. New York City makes about as poor a showing as anywhere, there being 165,000 less telephones here than there were in 1930. The greatest gain over 1930 has occurred in the Southeast, followed closely by the Pacific Coast and the Rocky Mountain States. While it is gratifying that the absolute number of telephones is at a new peak, the number of telephones per hundred of population for the country as a whole is still slightly lower than in 1930, although in the Southeast, Pacific and Rocky Mountain sections, it is higher than in 1930. Our current rate of growth is encouraging. During the first three months of this year the net gain in telephones was 215,000, as compared with a gain of 98,000 in the same period last year. The first two weeks in April show a gain of 34,000 as compared with 14,000 in the first two weeks in April last year. It is of interest that currently residence telephones have been showing somewhat larger gains, relatively speaking, than business telephones.

The number of toll and long distance messages is running well ahead of the corresponding months of last year and while not yet equal to the peak year of 1930, is slightly above the same months of 1937, which was the best year since 1930.

Many companies today, in addition to the usual statements of earnings and expenses, point out the percentages of revenue that go for wages, taxes, materials and supplies, interest and dividends, etc. It happens that our Annual Report for 1911 stated these figures in a chart that showed that 50 per cent of revenue went to employees, 5 per cent for taxes, 20 per cent for materials, rents, etc., 19 per cent for interest and dividends, and 6 per cent for surplus. Twenty-seven years later, the corresponding figures as shown in the Annual Report for 1938 were 49 per cent to employees, 14 per cent for taxes, 18 per cent for materials, rents, etc., and 19 per cent for interest and dividends, and nothing for surplus. You will note that the

only large differences between now and twenty-seven years ago are in taxes and surplus. Then 5 per cent went for taxes and 6 per cent was left for surplus. Now 14 per cent goes for taxes and there is nothing left for surplus.

Incidentally, in 1911, the Bell System, including the Western Electric Company, employed 146,000 persons and today it employs 292,000. The number of women then employed in the Bell System was 73,500—today it is 161,000. Since 1911, the population of the United States has increased some 38 per cent while the total number of employees in the industry, that is, both Bell and non-Bell, has increased 70 per cent. This increase in number of employees has taken place along with technical developments in equipment and methods which have improved the service and greatly extended its use. In addition to the 292,000 employed today in the Bell System, other telephone companies, which are not owned by, but connect with the Bell System, employ some 56,000 persons, and employees operating private branch switchboards number well over 100,000. Thus the telephone today provides employment directly for nearly one-half million people.

In passing it might be of interest to note that this is a business that requires a large investment in relation to the number of employees. There is some 17,000 of investment per Bell System employee—to state it in another way—it takes on the average, 17,000 of buildings and equipment—of tools if you like—to provide a job for one Bell System employee.

While our main interest is and will continue to be a constantly improving and expanding telephone service, I want to remind the stockholders that we have, purely as a by-product of this main interest, been pioneers in other fields. I mention a few of the more outstanding instances. Our radio broadcasting station WEAF, which we operated from 1922 to 1926, was a pioneer in the sale of radio program service; in 1925 we established a facsimile and telephoto service by wire; in 1927,

twelve years ago, we demonstrated successfully two-way television both by wire and radio. Our electrical recording method of making phonograph records as well as our development of the electric orthophonic phonograph gave a new impetus to the phonograph industry and our method of electrically recording sound, together with our powerful amplifiers and loud speakers, revolutionized the motion picture industry, changing it from silent to sound.

Now a word about our financial structure. In 1920, just prior to the change in the dividend rate of the American Telephone and Telegraph Company from $8 to $9 a share, the Bell System's funded debt was 45 per cent of its total capital obligations, including capital stock premiums and surplus. Today it is about 30 per cent. This marked improvement has taken place in spite of the fact that substantial charges were made to surplus in order to continue the dividend at the usual rate when it was not fully earned. Also, other substantial charges were made against surplus arising from the recent extensive program of refinancing which, while it results in large savings in the long run, necessitated large charge-offs to surplus for premiums and for unamortized discount on bonds redeemed in advance of their due date. Today, nearly 70 per cent of the System's capital obligations is equity capital, that is, capital stock, capital stock premiums and surplus. Taking the American Telephone and Telegraph Company by itself its debt was 36 per cent in 1920 and is now only 16 per cent of its total capital obligations. Or, stated the other way around, the equity capital, that is, the capital stock, capital stock premiums and surplus was 64 per cent and now is 84 per cent of the total capital obligations.

Perhaps to make the picture more complete, I should add that the Bell System has a depreciation reserve against a 4,500,000,000 telephone plant of about $1,250,000,000 or 28 per cent.

In closing, I again want to pay tribute to the devotion, efficiency and spirit of the employees of the Bell System, typically exemplified by the day to day handling of the service and more signally demonstrated in the September hurricane disaster referred to in the Annual Report. In this meeting, however, I hope you will permit me to pay another tribute—and I can only do so if you will be good enough to believe me when I say that I speak quite impersonally and that I am not even indirectly referring to myself. I want to pay a tribute to management. Your Company and its subsidiaries throughout the country have, in my opinion, never been better managed. The management, on the whole, has never been abler, more devoted to and more enthusiastic about the business. I think there is scarcely anything of more importance to the stockholders than the quality and character of the management, and it is a testimonial to the character of management that there were "no skeletons in the closet" to be exposed in the $1,500,000 investigation of which Congress is yet to receive a final report. The Bell System is the largest business organization in this country and probably in the world, practically all of its top executives have come up from the ranks, and the stockholders should and undoubtedly they do realize that it has been largely due to management that the Bell System has been able to steer successfully through depressed as well as boom times.

FIRST COMMERCIAL INSTALLATION OF CO-AXIAL CABLE PLANNED FOR SERVICE IN 1941

THE Long Lines Department of the American Telephone and Telegraph Company has placed with the Western Electric Company an order for the manufacture of a co-axial cable which will be installed between Stevens Point, Wis., and Minneapolis, Minn. The cost of the project, covering a distance of about 195 miles, is estimated at close to $2,000,000.

It is planned to have the cable in partial operation in 1941. It will be partly aerial and partly underground and can ultimately provide 480 telephone channels. While the cable can be made suitable for transmission of television, its use for that purpose is not contemplated at present.

Although an experimental cable of this type is now installed between New York and Philadelphia, the proposed cable represents the first installation of the co-axial type of construction to handle telephone and telegraph communications in regular service.

Telephone traffic over the route through Stevens Point to Minneapolis has been increasing steadily and facilities are being used practically to capacity. As this is a route connecting the East, including Chicago, with an important area containing a population of nearly a million, it is desirable to provide facilities adequate to take care of growth for some years in the future. Added reliability will be given to the service by substituting cable for aerial wire, as this area is frequently swept by sleet and snow storms.

When fully equipped with terminal and repeater apparatus, the cable will do the work of two ordinary long distance telephone cables. A development of the Bell Telephone Laboratories, it is contained in a lead sheath slightly less than an inch in diameter. Inside this sheath are four tubes of thin copper, each about the size of a lead pencil. Suspended in the center of each tube by fiber disks is a copper wire about the size of the lead in a pencil. These tubes and the central wires are the conductors, the cable being called co-axial because the tube and its central wire have the same axis.

Transmission over this novel type of conductor employs frequencies also used for radio. The impulses are wire-directed, however, and travel through a space which has been segregated electrically from all the rest of the space in the world by the tube. The tube not only guides these impulses

but protects them from fading, static, and other similar troubles of ordinary radio transmission.

The nature of co-axial transmission is such that it is necessary to use one of the tubes for transmission in one direction and a separate tube for transmission in the other. The other tubes will be spare. High frequency currents are used to carry impulses along the co-axial channels. In all, the frequencies transmitted will cover a band of 3,000,000 cycles. From this band can be obtained hundreds of channels of various widths—narrow ones for telegraph and teletypewriter circuits, wider ones for telephone and telephotograph, and still wider for the high quality required in broadcasting network service.

The function of the terminal apparatus is to raise voices and signals to high frequencies at the sending end and drop them back to their normal voice frequencies at the receiving end. In order that all of these impulses may be effectively separated from each other, this apparatus is necessarily intricate. The amplifiers, otherwise known as "repeaters," are of special design, capable of amplifying simultaneously the entire group of messages which the cable handles, and they are spaced closer together than on the ordinary long distance cable.

Whereas each circuit of the usual type of long distance cable on this route would have a total of five repeaters, installed at the two terminals and at stations approximately fifty miles apart along the route, the new co-axial cable will employ about forty repeaters, installed at the terminals and in stations about five miles apart. Since each circuit in the old style cable requires a repeater at each station, for 480 circuits there would be 2400 repeaters, while in the case of the co-axial cable, 80 repeaters handle the entire capacity of the cable. These repeaters, together with the terminal equipment, will employ approximately 3000 vacuum tubes of a special type. They will be able to handle a total of 480 conversations, however—an average of slightly more than six tubes per circuit—whereas an old

style cable installation would require twenty vacuum tubes for each of the 480 circuits.

BARKLIE HENRY, G. PEABODY GARDNER, JR., ARE ELECTED DIRECTORS

TWO new directors have been elected to the Board of the American Telephone and Telegraph Company since the first of year. At the meeting of the Board on January 18, Barklie Henry was elected to fill the vacancy caused by the death of Edward D. Duffield. Mr. Henry is President of the Association for Improving the Condition of the Poor and is a director of the United States Trust Company. At the meeting of the Board on February 15, G. Peabody Gardner, Jr., of Boston, was elected to fill the vacancy caused by the resignation of George Peabody Gardner, who had been a director since 1912.